WELFARE GAINS FROM SUPPLY STABILIZATION IN THE ORANGE INDUSTRY OF FLORIDA

By

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1975

ACKNOWLEDGEMENTS

The author expresses sincere appreciation to the Chairman of his Supervisory Committee, Dr. Max R. Langham, for his guidance in all phases of this research. No less appreciation is expressed to Dr. James A. Niles whose insights on the structure and operation of the marketing system of the frozen concentrated orange juice industry of Florida were invaluable for the econometric aspects of the research. To the other members of his Supervisory Committee, Dr. Frederick O. Goddard and Dr. Leo Polopolus a special word of thanks.

The cooperation of all personnel of the Economic Research Department, Florida Department of Citrus, was excellent and for this the author thanks the Director of that unit, Dr. W. Bernard Lester and all the members of his staff--especially Dr. Ronald W. Ward who read the drafts and participated in the final exam. The author is also grateful to Janet Eldred for typing the various drafts and to LeAnne van Elburg for typing the final copy.

The financial support of the Agricultural Development Council, New York, throughout the years of graduate study is deeply appreciated. To Dr. A. R. Stevenson and Miss Grace Tongue, who were responsible for the administration of the A. D. C. Fellowship Award, and who took the interest of the author as their own, a deep note of appreciation. The same is expressed to Dr. Clifton R. Wharton, Jr. who began my interest in agricultural economics.

TABLE OF CONTENTS

		Page
ACKNOWLEDGEMENTS		ii
LIST OF TABLES		v
LIST OF FIGURES		vii
ABSTRACT		viii
CHAPTER		
I	INTRODUCTION	1
	Objectives	2
	FCOJ and the Florida Orange Industry	4
II	ECONOMIC FRAMEWORK FOR WELFARE CONSIDERATIONS	9
	Welfare and the Surplus Concept	9
	Stable Market Conditions	11
	Stochastic Market Conditions	14
	With Market Intermediaries	18
	Price and Supply Stabilization	23
	Market Intermediaries	24
	Consumers	27
	Primary Producers	28
	Society	30
III	SUPPLY STABILIZATION AND NET WELFARE GAINS IN THE FLORIDA FCOJ INDUSTRY	32
	Supply Stabilization	35
	Prior Research on Parameter Estimates	37
	The Model	39
	Primary (Grower) Supply	41
	Processor (Wholesale) Supply	41
	Retail Supply	43
	Consumer (Retail) Demand	45
	Retailer Demand (At Processor Level)	45
	Processor (On-tree) Demand	46
	Structural Change in the FCOJ Industry	46
	Statistical Considerations	47

Page

The Data 50
Total Availability and the Amount of FCOJ Sold 50
Prices 51
Population, Price Indices, and Personal Disposable Income 52
Warehousing Costs 52
Period of Study 52
Statistical Results 54
Behavioral Functions 54
Choice of Estimation Technique 58
Welfare Considerations 61
Supply and Demand Variances 62
Net Welfare from Perfect Stabilization 63
Net Welfare from the Florida Reserve Pool 65

IV SUMMARY AND CONCLUSIONS 69
Some Long-run Implications 73
Suggestions for Administration of the Florida Reserve Pool 75
Suggestions for Future Research 77

APPENDIX A SUMMARY OF DATA 79

APPENDIX B SUMMARY OF THE PROPOSED FLORIDA FCOJ RESERVE POOL 85

APPENDIX C PROOF OF FORMULAE USED 90

APPENDIX D PREDICTING THE SEASONAL PACK OF FCOJ 93
Prediction Equations 95
Seasonal Production of Oranges 95
Yield per tree 98
Tree numbers 104
Seasonal FCOJ Pack 104
Performance of the Prediction Equations 107
Seasonal Orange Production 107
Seasonal FCOJ Pack 111
Implications for Reserve Pool Operations 115

REFERENCES CITED 116

BIOGRAPHICAL SKETCH 119

LIST OF TABLES

Table		Page
1	Utilization of Florida orange production, 1965-66 through 1973-74 seasons	5
2	Summary of statistical results for the FCOJ markets	55
3	Quantity-price relationships for the FCOJ markets	59
4	Variance estimates of the supply and demand relationships for the FCOJ market	63
5	Net per capita welfare gains to the market participants of the U. S. domestic FCOJ market, with respect to perfect supply stabilization	64
6	Net per capita welfare gains to the market participants of the U. S. domestic FCOJ market, with respect to the Florida reserve pool	67
A.1	On-tree prices, quantities of oranges processed, and yield in gallons of FCOJ per box for Florida oranges (Round and Temples) by seasons, 1957-58 through 1973-74	80
A.2	Pack, exports, purchases by military and government, inventory, and movement of FCOJ by seasons, 1957-58 through 1973-74	81
A.3	U. S. population, consumer price index, total personal disposable income, costs of FCOJ warehousing, and average retail price of FCOJ by seasons, 1957-58 through 1973-74	82
A.4	Retail price FCOS, FOB price for FCOJ, wholesale price index, and food price index by seasons, 1957-58 through 1973-74	83
A.5	Basic statistics of variables in the model estimated	84

Table		Page
B.1	Excerpts from Attachment A to Marketing Order 105-6.01, The Diversion Table	86
B.2	Attachment B to Marketing Order 105-6.01, Release Price Table	88
D.1	Average yield of Florida oranges per tree by age class and variety, eight year season average, 1965-66 through 1973-74	96
D.2	Tree density per acre of Florida commercial oranges, by age and by variety in December 1973	97
D.3	Estimated effect of density and age on yield per acre	99
D.4	Estimated effect of density and age on yield per tree	99
D.5	Yield per tree by age class, as estimated by FCLRS and Phillips	101
D.6	Estimated yield per tree by age class and variety	101
D.7	Estimated yield per tree, by variety and age for Florida oranges	103
D.8	FCOJ yields per box for Florida oranges by seasons, 1960-61 through 1973-74	106
D.9	Actual and estimated seasonal production of Florida oranges, 1965-66 through 1973-74 with estimates extending through 1977-78	108
D.10	Actual and estimated seasonal pack of FCOJ by seasons, 1965-66 through 1973-74 with estimates extending through 1977-78	112

LIST OF FIGURES

Figure		Page
1	Utilization of Florida orange production, 1965-66 through 1973-74 seasons	6
2	The demand curve	9
3	Consumers' and producers' surplus	10
4	Producers' surplus as affected by different intercept values of the supply function	12
5	Consumers' and producers' surplus under stochastic market conditions	16
6	Consumer, middlemen, and producer surplus resulting from a shift in an inelastic supply function	20
7	Economic surplus due to consumers (S_c), market intermediaries and growers (S_p), and growers (S_g)	20
8	Surplus due to consumers (S_c), all producers (S_p), processors and growers (S_w), and growers only (S_g)	33
9	Supply and demand relationships for the FCOJ market	60
D.1	Estimated average yield of Florida orange trees, by age and variety	102
D.2	Actual and estimated seasonal production of Florida oranges	110
D.3	Actual and estimated seasonal pack of FCOJ, in million gallons	113

Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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By

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June, 1975

Chairman: Max R. Langham
Major Department: Food and Resource Economics

The major objectives of this study were to review the literature related to the welfare considerations of supply stabilization; to consolidate and extend such studies so as to provide a generalized view of the welfare effects of supply stabilization on all participants in a marketing system; and to apply the resulting conceptual model to evaluate the net welfare gains to the market participants in the Florida orange industry should a supply stabilization scheme be introduced.

The two-party consumer-producer welfare framework of Frederick Waugh, Walter Oi, and Benton Massell was extended to a four-party case with the market participants being consumers, retailers, processors, and growers. The net welfare positions of these market participants subsequent to the implementation of a supply stabilization scheme were developed.

Using historical utilization of Florida orange production, it was argued that changes in net welfare due to supply stabilization in all Florida orange product markets except the frozen concentrate orange juice (FCOJ) markets, would be zero.

Three sets of estimates of the supply variances, as well as slope

estimates for the supply and demand functions at the retail, processor, and grower levels of the FCOJ industry, were obtained by using three separate estimation techniques on time series data. The estimation techniques were ordinary least squares (OLS), two stage least squares (2SLS), and three stage least squares (3SLS). On an a priori basis all coefficient signs were as expected for the three estimation procedures. The values of the coefficients were also not appreciably different from each other among the estimation techniques used.

A prediction equation for the annual FCOJ pack was also developed to provide administrators of the FCOJ reserve (stabilization) pool (should one be implemented) with some idea as to the trend of the annual FCOJ pack. The mean of deviations of actual production from the estimated trend was not significantly different from zero. Variations in tree numbers, age, variety, and density of stand, account for an estimated 60.41 percent of the total seasonal variation in production. Implications of supply trends for pool management were discussed.

The net welfare of the four market participants in the FCOJ industry were evaluated using the 2SLS estimates. Had a supply stabilization scheme been implemented in 1974, the estimated net loss to consumers would have been 8.53 million dollars. The net gains to growers, retailers, and processors would have been 21.37, 3.05, and 0.01 million dollars respectively. These values were in 1967 dollars. The results indicate that processors would probably not be interested in the implementation of a supply stabilization scheme for the industry.

CHAPTER I
INTRODUCTION

It is dissatisfaction with the performance of particular free markets that culminates in the emergence of organizations whose purpose is to manipulate the market to achieve the performance criteria that is desired. The most recurring argument in support of the existence of a marketing authority is that price variations need to be reduced. Implied, indeed sometimes even explicitly stated, is that supply stabilization leads towards price stabilization, and thereby contributes to the betterment of society. The Frozen Concentrated Orange Juice Pooling Act[1] enacted by the Florida Legislature in 1974 is one current example. It provides for the existence of a reserve pool of frozen concentrated orange juice (FCOJ) for the orange industry of Florida so as ". . . to establish and maintain such orderly marketing conditions for FCOJ as will provide, in the interest of producers and consumers, an orderly flow of supply thereof to market as to avoid excessive fluctuations in supplies, and it is hereby determined that the disruption of the orderly marketing of FCOJ by excessive fluctuations in supply impairs the purchasing power of citrus producers and unreasonably reduces the value of those agricultural assets . . . ."[2]

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[1]Florida Statutes Section 601.159. This legislation was brought about as a result of wide fluctuations in prices received by Florida orange growers. Appendix Table A.1 shows the seasonal average on-tree prices per box of round oranges received by orange growers in Florida from the 1957-58 to the 1973-74 seasons. The prices ranged from $0.96 to $4.43 with an average of $2.06. The coefficient of variation is 0.40.

[2]Florida Statutes Section 601.159 (1a). For a summary on administration and operation of the FCOJ reserve pool, refer to Appendix B.

Whether supply stabilization by itself will lead to price stabilization, and whether the latter will directly contribute to the benefit of society, or indirectly provides the conditions that lead to increases in welfare are issues not fully settled to the satisfaction of economists. Yet, like it or not, markets are being manipulated as a matter of policy, and supply stabilization schemes are instituted to achieve price stabilization. The need for a detailed examination of supply and price stabilization is clear.

Supply and price stabilization arguments are necessarily associated with welfare considerations since the latter are the arguments presented for supply (price) stabilization to be accepted as a matter of policy. While acknowledging that there exist many measures of welfare, this study will only use the surplus concept as the measure of welfare. This is not to argue that it is best but only that it is generally accepted as an empirically operational measure of welfare, and that it is particularly suited for the evaluation of welfare positions arising from changes in market structure.

Objectives

The objectives of this study are:

a) To review the literature of supply (price) stabilization studies, especially those which relate to welfare considerations;

b) To consolidate these studies and to provide a generalized view of supply (price) stabilization effects on producers, processors, distributors, and consumers; and

c) To evaluate the Florida FCOJ industry based on the

conceptual model established, so as to provide empirical evidence of the potential gains or losses to the market participants that may arise as a consequence of the activities of the reserve pool.

The overall objective is to provide a better understanding of the welfare consequence of supply (price) stabilization, in particular those that may arise from potential activity of the proposed FCOJ reserve pool.

The enabling legislation for a reserve pool was directed toward the FCOJ industry. The next section of this chapter establishes that much of the variation in total orange production is absorbed by FCOJ utilization. This provides a basis for restricting the study on the effects of the FCOJ reserve pool to the FCOJ component of the orange industry.

FCOJ and the Florida Orange Industry

Oranges produced in Florida may be sold into the fresh market or processed into frozen concentrate orange juice (FCOJ), chilled orange juice (COJ), or canned single strength orange juice (CSSOJ). These are the principal outlets. Other products are made, but they are insignificant relative to the total utilization of the crop. Table 1 gives the actual (historical) utilization of oranges produced in Florida. It may be discerned from this table, as well as from Figure 1 that annual[3] orange production is increasing with time. This annual increase is not steady but is subject to large fluctuations. The variance[4] of the total annual orange production of Florida for the seasons 1965-66 through 1973-74 is 636.45 million boxes.

This annual variation in orange production is largely absorbed by the FCOJ product market. The correlation between the annual FCOJ pack and total production (in boxes) is almost perfect ($r = .992$) and the variance of the annual utilization of oranges in the FCOJ product market is 634.96 million boxes of oranges. Figure 1 shows the parallel movements in the oranges utilized by the FCOJ product market and the total annual orange production.

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[3]The intention of having a reserve pool is to reduce the market effect of annual fluctuations in the supply of Florida oranges. Annual data is thus only considered to be of relevance in all subsequent discussions.

[4]$\frac{\Sigma(O_t - \overline{O})^2}{n - 1}$ where O_t = value of observation in season t

$\overline{O}$ = average value of all observations in the sample

n = 9 = number of observations (years)

Table 1.--Utilization of Florida orange production, 1965-66 through 1973-74 seasons

Season	Fresh	COJ	CSSOJ	Other[a]	Sub-total	FCOJ	Total
	----------	----------	----------	million boxes	----------	----------	----------
65-66	17.87	12.32	6.87	1.53	38.59	61.81	100.40
66-67	21.18	16.48	8.75	1.34	47.75	96.75	144.50
67-68	20.06	16.00	5.88	1.09	43.03	61.97	105.00
68-69	15.52	17.85	8.10	0.61	42.08	92.12	134.20
69-70	16.06	18.64	7.07	0.39	42.16	100.74	142.90
70-71	16.40	19.77	7.67	0.06	43.78	103.52	147.30
71-72	13.15	19.50	6.48	-1.23	37.90	104.40	142.30
72-73	14.67	20.48	8.00	-0.56	42.59	132.21	174.80
73-74	13.01	20.48	6.59	-1.45	38.63	132.47	171.10

[a]Includes statistical discrepencies from reporting sources.

Source: Florida Citrus Mutual Annual Statistical Report, various issues.

Note: COJ = chilled orange juice
CSSOJ = canned single strength orange juice
FCOJ = frozen concentrated orange juice

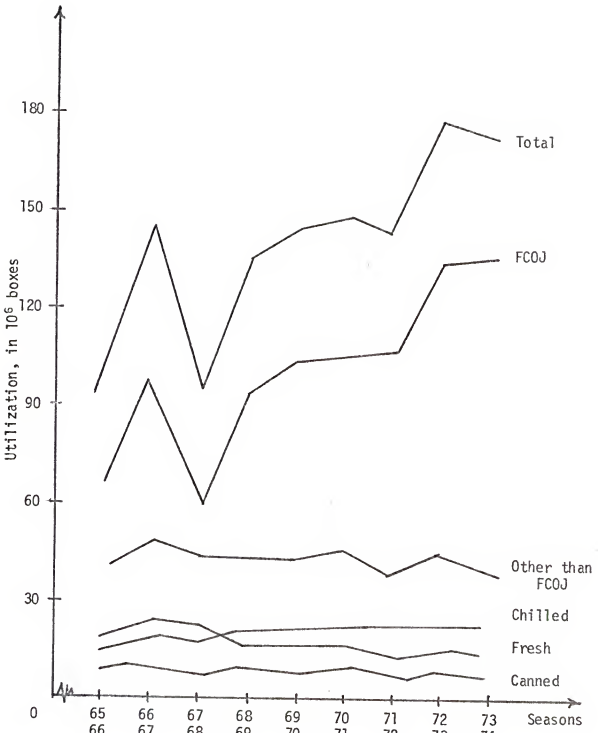

Figure 1.--Utilization of Florida orange production, 1965-66 through 1973-74 seasons

The disposal of oranges into the non-FCOJ product markets has been relatively stable through the years. This is supported by the fact that the correlation of orange utilization in the non-FCOJ product markets and total annual orange production is very low (r = .07). This uncorrelatedness between the quantities disposed of in the non-FCOJ markets and total annual orange production may be observed in Figure 1. It is apparent that the allocation of oranges into non-FCOJ product markets is quite stable and accounts for very little of the variation of total production.

A stable annual utilization of oranges by the non-FCOJ markets does not imply that the utilization of oranges in each and every non-FCOJ product market is also stable. The amount of oranges utilized by the chilled orange juice market appears to be steadily increasing through the years. This increase is counter-balanced by the steady decline in the total amount of oranges utilized by the fresh market. It is only in the canned single strength orange juice market that the amount of oranges utilized holds steady with the passage of time.

Since the aggregated utilization of oranges in the non-FCOJ product markets has been very stable through time, it is assumed that the operation of any orange diversion plan (into FCOJ and storage, together with releases from storage) by a marketing authority will not[5] affect these

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[5]The four markets of oranges--fresh, COJ, CSSOJ and FCOJ--are all markets which are differentiated by form, hence really interconnected; severe changes in the basic conditions of supply (and hence prices) in any one of the product differentiated markets will cause supply and/or demand adjustments to occur for the remaining markets. Given the present clearing conditions for the FCOJ market where fluctuations of nearly 20 million boxes are absorbed annually without causing undue difficulty, the operation of a reserve pool, if it does not generate additional instability to the FCOJ market, will not affect the basic conditions that operate in the four major markets for Florida oranges. As proposed, the pooling board is producer orientated; thus it is very unlikely to create problems for the entire orange industry. Further, the maximum allowed for diversion is 10 percent of the crop. This will, at least in the next few years, be less than 20 million boxes.

markets. The net change in welfare brought about by the existence of a pooling board would be zero for the non-FCOJ product markets. That is, non-zero net welfare gains (or losses) as a result of the operations of a reserve pool for the orange industry would occur only in the FCOJ market.[6]

The second chapter determines the algebraic expressions to be used for evaluating the net welfare of consumers, retailers, processors, and growers in the FCOJ market that arises from supply stabilization. This is followed by Chapter III in which the relevant parameters from prior research are listed. Failing to obtain a complete set of the numerical estimates of the relevant parameters from prior studies, econometric techniques were employed to estimate the parameters. With the resulting estimates, the net welfare positions of the four market participants were evaluated. Chapter IV follows with a summary of the study, together with some suggestions for the administrators of the Florida reserve pool (if one should be implemented) as well as suggestions for future research.

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[6]This inference holds only if future behavioral patterns of orange producers remain identical to those of the past. Such an assumption must necessarily be made for all analyses associated with human behavioral functions. Supply functions are no exception.

CHAPTER II
ECONOMIC FRAMEWORK FOR WELFARE CONSIDERATIONS

Welfare and the Surplus Concept

Of prime concern to all participants in the market when some form of market control is to be introduced is whether the proposed market control will bring about an increase, no change, or a reduction in their welfare position. A measure of the welfare position of market participants was first formulated by Dupuit in 1844 and then taken up by Marshall (Nath, 1969, p. 165). This is the surplus concept.

The market demand function may be viewed as a schedule which shows how much consumers will be willing to pay for each additional unit purchased over and above the amount that they have already acquired. If the area of quadrilateral A in Figure 2 is taken to represent the amount that consumers will be willing to pay to purchase the initial unit, then quadrilateral B will represent the amount that consumers will be willing to spend in order to acquire the second unit. In like manner C represents

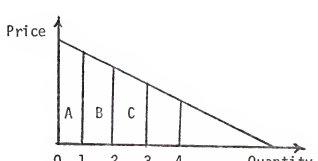

Figure 2.--The demand curve

the amount that consumers will be willing to pay to acquire the third unit, and so on.

In practice, consumers do not pay the full amount that they are willing to pay for each and every unit of the commodity purchased, but rather the price that prevails in the market. In a free market as represented by Figure 3, the actual amount spent by consumers in purchasing the amount Q_e is equivalent to the area of the rectangle $(S_p + C)$. The difference in what consumers actually pay to acquire Q_e units and what they would be willing to pay is defined as the consumers' surplus. This is the area S_c.

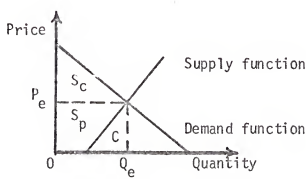

Figure 3.--Consumers' and producers' surplus

The supply function may also be viewed as one which indicates the minimum amount that must be received by producers in order to induce them to sell an additional unit over and above that which they have sold. In practice, producers are not paid the minimum that will induce them to sell commodity produced to consumers. From Figure 3, the amount actually received by producers is the area $(S_p + C)$, rather than the area C alone. The difference in what producers actually receive and that which they

would be satisfied with in order to sell Q_e is given by the area S_p. This is the producers' surplus.

If the market participants are defined to belong to the same society under consideration, then the total gains to society may be measured by the sum of both the producers' and consumers' surplus, provided no externalities to other markets occur as a result of the operations of this market. For the purpose of this study, the equivalency of one unit of producers' surplus and one unit of consumers' surplus is assumed. A constant marginal utility per unit of surplus is also assumed. It is only with such assumptions that discussions on welfare gains (losses) to society as a result of changes in the market structure can begin.

Marketing authorities may therefore seek to increase (maximize) producers' surplus, or consumers' surplus, or the sum of the two. In the latter case it may (or may not) involve itself in trying to distribute the gains equitably among the market participants.

Stable Market Conditions

Consider a free market with linear supply and demand curves described by the functions

(2.1a) $Q^D = A - aP$; $A, a > 0$

(2.1b) $Q^S = B + bP$; B unconstrained, $b > 0$

where Q^D = quantity demanded at price P, Q^S = quantity supplied at price P, with A, B, a, and b the associated constants. When equilibrium conditions prevail, the values of the equilibrium price P_e and that of the equilibrium quantity Q_e will be

(2.2a) $P_e = \frac{A - B}{a + b}$

(2.2b) $Q_e = \frac{Ab + aB}{a + b}$

The positive restrictions on parameters a and b do not ensure positive values for P_e and Q_e. Since only positive price and quantity values are of relevance, we impose the additional constraints

(2.2c) $A - B > 0$

(2.2d) $Ab + aB > 0$

which makes P_e and Q_e always positive.

The producers' surplus S_p, defined as the area under the equilibrium price but above the supply function is obtained by using geometry.[1] From Figures 4a and 4b, the producers' surplus will be given by the sum of a rectangle and a triangle, and by a triangle alone respectively.

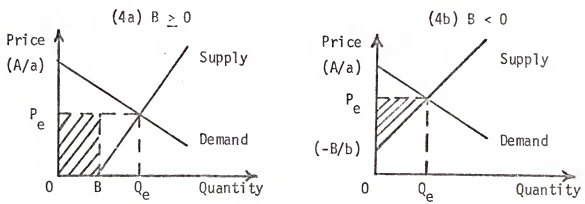

Figure 4.--Producers' surplus as affected by different intercept values of the supply function

[1]This approach takes advantage of the linearity of the functions used. In general, the supply function may be integrated to give the producers' surplus. From Figure 4 the limits of integration will be the origin to P_e, or $(-B/b)$ to P_e, depending on whether the supply intercept is positive or negative, respectively.

Upon evaluation,[2] the following formulae may be obtained.

$$(2.3a) \quad S_p = \frac{Q_e^2 - B^2}{2b} \quad \text{if } B \geq 0$$

$$(2.3b) \quad S_p = \frac{Q_e^2}{2b} \quad \text{if } B < 0$$

Similarly, the consumers' surplus, defined as the area under the demand curve but above the equilibrium price is the area of a triangle and may be obtained as (2.4).

$$(2.4) \quad S_c = \frac{Q_e^2}{2a}$$

If all market participants belong to the same society, then the sum of both the producers' and consumers' surplus will be the welfare accruing to society given the prevailing market system. To allow for the validity of the addition, it is assumed that an equivalency of one unit of producers' surplus and one unit of consumers' surplus exists, and that external effects arising from the existence of the market under consideration on other sectors of society is negligible. The surplus to society may be written as (2.5).

$$(2.5a) \quad S_T = S_p + S_c$$

$$(2.5b) \quad = \frac{(a + b)Q_e^2 - aB^2}{2ab} \quad \text{if } B \geq 0$$

$$= \frac{(a + b)Q_e^2}{2ab} \quad \text{if } B < 0$$

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[2]Derivations of the formulae used in this chapter are presented in Appendix C.

Stochastic Market Conditions

If stochastic elements are introduced for the intercepts of both the demand and supply functions, we have[3] for the market demand and supply functions respectively

(2.6a) $Q^D = A - aP + u$

(2.6b) $Q^S = B + bP + v$

where u and v are the additive stochastic disturbances for the market demand and supply functions respectively. All other symbols remain identical to those considered earlier. Two assumptions are now made on the stochastic elements u and v. Firstly, they do not on the average affect

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[3]This is the random intercept model. Following Hildreth and Houck (1968), Swamy (1970), and Langham and Mara (1973), the more general case of the random coefficient model is as follows:

(2.6g) $Q^D = A + u_0 - (a + u_1)\ P$

(2.6h) $Q^S = B + v_0 + (b + v_1)\ P$

with u_0, u_1, v_0, and v_1 the stochastic terms associated with the model. When equilibrium conditions prevail for the market, the equilibrium price P_e and equilibrium quantity Q_e may be expressed as:

(2.7f) $P_e = (A - B + u_0 - v_0)/(a + b + u_1 + v_1)$

(2.7g) $Q_e = [(A + u_0)(b + v_1) + (B + u_0)(a + u_1)]/(a + b + u_1 + v_1)$

The mathematical expectations of P_e and Q_e may not be obtained without additional assumptions on the distributional forms of u_1 and v_1. For example, if (2.7f) is rewritten as

$$P_e(a + b + u_1 + v_1) = A - B + u_0 - v_0$$

the expectation on both sides of the equality will be

$$(a + b)\ E(P_e) + E[(u_1 + v_1)\ P_e] = A - B$$

Without any additional assumptions over and above those given in (2.6c) through (2.6f) in the text, the expectation of the equilibrium price cannot be determined. The same applies to the variance estimate of the equilibrium price.

the intercept values of the demand and supply functions. Secondly, all factors that do influence the value of u are not related to the factors affecting the value of v, and vice versa. More explicitly, we have

(2.6c) $E(u) = E(v) = 0$

(2.6d) $V(u) = \sigma_{DD} = E(u^2) \geq 0$

(2.6e) $V(v) = \sigma_{SS} = E(v^2) \geq 0$

(2.6f) $Cov(uv) = \sigma_{DS} = E(uv) = 0$

When equilibrium conditions prevail for the market, i.e., $Q^D = Q^S$, the values for the equilibrium price P_e and the equilibrium quantity Q_e are

(2.7a) $$P_e = \frac{A - B}{a + b} + \frac{u - v}{a + b}$$
$$= \overline{p} + e_1$$

(2.7b) $$Q_e = \frac{Ab + aB}{a + b} + \frac{av + bu}{a + b}$$
$$= \overline{q} + e_2$$

The stochastic elements of P_e and Q_e, e_1 and e_2, are linear combinations of u and v. Thus we have the following:

(2.7c) $$V(P_e) = \sigma_{pp}$$
$$= E(e_1^2)$$
$$= \frac{\sigma_{DD} + \sigma_{SS}}{(a + b)^2}$$

(2.7d) $$V(Q_e) = \sigma_{qq}$$
$$= E(e_2^2)$$
$$= \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{(a + b)^2}$$

$$(2.7e)\quad \mathrm{Cov}(P_eQ_e) = \sigma_{pq}$$

$$= E(e_1e_2)$$

$$= \frac{b\sigma_{DD} - a\sigma_{SS}}{(a+b)^2}$$

The introduction of stochastic elements into the market supply and demand functions to analyze the effects of price stabilization is not new. Waugh (1944) essentially used a stable demand function with a fluctuating supply function to demonstrate the effects of price stabilization from the viewpoint of consumers. Walter Oi (1961) used the converse (i.e. a stable supply function and a fluctuating demand function) to demonstrate the effects of price stabilization from the producers' viewpoint. Massell (1969) consolidated the two studies to consider the effects of price stabilization to producers and consumers in a market with both fluctuating demand and supply functions.

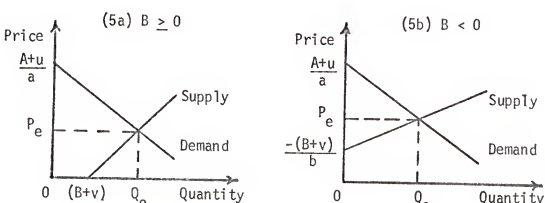

Figure 5.--Consumers' and producers' surplus under stochastic market conditions

Figures 4 and 5 are identical except that a stochastic term is individually associated with the intercepts A and B in the latter (stochastic) case. Substituting (2.7b) into (2.3), keeping in mind that the intercept value B is now subject to an additive error term v, the equivalent expression for producers' surplus of (2.3) may be written as (2.8).

$$\text{(2.8a)} \quad S_p = \frac{\overline{q}^2 - B^2}{2b} + \frac{e_2^2 + 2\overline{q}e_2 - v^2 - 2Bv}{2b} \quad \text{if } B \geq 0$$

$$\text{(2.8b)} \quad S_p = \frac{\overline{q}^2}{2b} + \frac{e_2^2 + 2\overline{q}e_2}{2b} \quad \text{if } B < 0$$

The producers' surplus, in the expected sense, is obtained by taking the expectations[4] of (2.8). This gives (2.9).

$$\text{(2.9a)} \quad E(S_p) = \frac{\overline{q}^2 - B^2}{2b} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2b(a+b)^2} - \frac{\sigma_{SS}}{2b} \quad \text{if } B \geq 0$$

$$\text{or,} = \frac{\overline{q}^2 - B^2}{2b} + \frac{b\sigma_{DD} - (b+2a)\sigma_{SS}}{2(a+b)^2}$$

$$\text{(2.9b)} \quad E(S_p) = \frac{\overline{q}^2}{2b} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2b(a+b)^2} \quad \text{if } B < 0$$

$$\text{or,} = \frac{\overline{q}^2}{2b} + \frac{b\sigma_{DD} - (b+2a)\sigma_{SS}}{2(a+b)^2} + \frac{\sigma_{SS}}{2b}$$

By adopting a similar approach, the consumers' surplus under stochastic conditions may be obtained from (2.4) and (2.7b), and expressed as (2.10), and the value in the expected sense[5] as (2.11).

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[4]It may be noted that Massell's formula for the stochastic component associated with producers' surplus only relates to (2.9a). It is not universally applicable in that when B < 0, expression (2.9b) becomes appropriate for use. Expressions (2.9a) and (2.9b) differ by the inclusion of the term $\frac{\sigma_{SS}}{2b}$ in (2.9b)

[5]Massell's formula for the stochastic component of consumers' surplus is thus not complete, the term $\frac{\sigma_{DD}}{2a}$ being excluded from consideration.

$$(2.10)\quad S_c = \frac{\bar{q}^2}{2a} + \frac{e_2^2 + 2\bar{q}e_2}{2a}$$

$$(2.11)\quad E(S_c) = \frac{\bar{q}^2}{2a} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2a(a+b)^2}$$

$$\text{or, } = \frac{\bar{q}^2}{2a} + \frac{a\sigma_{SS} - (a+2b)\sigma_{DD}}{2(a+b)^2} + \frac{\sigma_{DD}}{2a}$$

The surplus due to society (in the expected sense), may then be written[6] as (2.12).

$$E(S_T) = E(S_p) + E(S_c)$$

$$(2.12a)\qquad = \frac{(a+b)\bar{q}^2 - aB^2}{2ab} + \frac{b\sigma_{DD} - a\sigma_{SS}}{2a(a+b)} \quad \text{if } B \geq 0$$

$$(2.12b)\qquad = \frac{(a+b)\bar{q}^2}{2ab} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2ab(a+b)} \quad \text{if } B < 0$$

With Market Intermediaries

No attention has been paid thus far to the definition of the commodity involved in a two party consumer producer market interaction. With the exclusion of a primitive marketing system, the demand function of consumers is in reality, a joint demand function for the good in its intrinsic sense, as well as for the associated marketing services that add differing amounts of space, time, and form utilities to the physical product. Similarly, the supply at retail is a joint supply function of

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[6] Massell's formula for the stochastic element of the surplus to society is not identical to that of (2.12a) due to the exclusion of the term $\frac{\sigma_{DD}}{2a}$ in the surplus to consumers; as for (2.12b), Massell's formula differed by the exclusion of the term $(\frac{\sigma_{DD}}{2a} + \frac{\sigma_{SS}}{2b})$. These differences arise due to the difference in the surplus expressions for producers as well as consumers.

both the primary producer and that of the middlemen. Unless one is satisfied to examine for the welfare effects of supply (price) stabilization between consumers and the aggregation of primary producers, processors, and distributors (retailers), the two-party consumer-producer framework as developed earlier will be inadequate for use. In order to examine for the effects that marketing intermediaries have on the marketing system while they act to further their own interests (and conversely, on the effects that changes in the marketing system brought about by legislation would have on middlemen welfare), the theoretical framework must be extended to include market intermediaries.

Consideration of middlemen welfare as a result of changes in the marketing system that may be brought about by governmental actions, is not new. Carmen and Youde (1973) in their analysis on welfare gains to society as a result of tax incentives[7] to primary producers, regarded middlemen as one important component of society. Treating the present tax structure for perennial crops in the United States as a defacto price subsidy, the effect of an alternative tax structure was estimated within a deterministic economic surplus framework. Any adverse change in the tax structure to producers will result in a backward shift of the perfectly inelastic supply function from S to S' as illustrated in Figure 6. A net reduction of consumers' surplus by the amount (A + B) results. The net reduction in middlemen welfare will be the area (C + D + E - A), while that for producers' surplus the area (F - C).

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[7]Development costs for all orchard crops, except citrus and almonds, may still be treated as a current deduction in computing U. S. federal income taxes. Since 1970, development costs associated with citrus and almonds may not be treated as a current deduction, but only as a capitalization (exempt from taxes and interest) to be spread over the average bearing life of the perennial. This results in a lower present value tax deduction for the grower. Capitalization of development costs is the alternative tax structure considered.

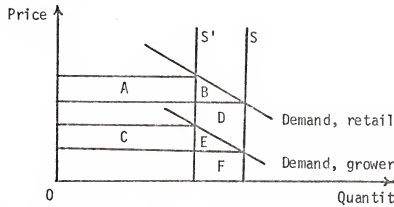

Figure 6.--Consumer, middlemen, and producer surplus resulting from a shift in an inelastic supply function

The model as developed by Carmen and Youde is a special case with the supply functions at both the grower and the retail level being perfectly inelastic and identical. It may be generalized by allowing the supply functions to be elastic, and by eliminating the restriction that the quantities purchased from growers by market intermediaries be identical to that sold by the latter to consumers within the same marketing season. Figure 7 then is the generalized case of Figure 6.

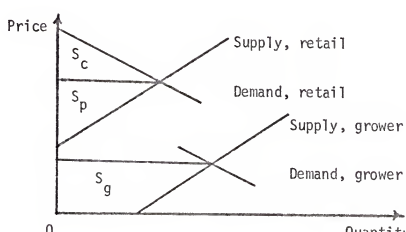

Figure 7.--Economic surplus due to consumers (S_c), market intermediaries and growers (S_p), and growers (S_g)

The welfare of consumers for a particular commodity, together with its associated marketing services may be represented graphically by the triangle S_c in Figure 7. With the additional of the subscript r to all parameters in (2.11) to denote that the retail market is under consideration, the welfare of consumers may be represented by (2.13).

$$(2.13) \quad E(S_c) = \bar{S}_c + \frac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2a_r(a_r + b_r)^2}$$

$$\text{where } \bar{S}_c = \frac{\bar{q}_r^2}{2a_r}$$

Since space, time, and even form utilities are attached to the commodity as it passes through the hands of market intermediaries, the supply function at the retail level will be a joint supply function of both commodity and associated marketing services. The economic surplus denoted by the area S_p in Figure 7 will be the surplus going to the aggregation of all producers, i.e., primary producers as well as market intermediaries. The surplus going to primary producers alone is given by the area S_g. Middlemen surplus may then be obtained as a difference. If S_m is taken to represent the surplus due to market intermediaries, then expression (2.14) defines an identity.

$$(2.14) \quad S_m = S_p - S_g$$

With the addition of subscripts r and g to (2.9) so that the two market levels (retail and grower) may be distinguished, the aggregated producers' surplus and that of the growers' is obtained as (2.15) and (2.16). Middlemen surplus may then be obtained by substituting (2.15) and (2.16) into (2.14). This gives (2.17).

$$(2.15a)\quad E(S_p) = \bar{S}_{p1} + \frac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2b_r(a_r + b_r)^2} - \frac{\sigma_{SSr}}{2b_r} \quad \text{if } B_r \geq 0$$

$$= \bar{S}_{p1} + \frac{b_r\sigma_{DDr} - (b_r + 2a_r)\sigma_{SSr}}{2(a_r + b_r)^2}$$

$$\text{where } \bar{S}_{p1} = \frac{\bar{q}_r^2 - B_r^2}{2b_r}$$

$$(2.15b)\quad E(S_p) = \bar{S}_{p2} + \frac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2b_r(a_r + b_r)^2} \quad \text{if } B_r < 0$$

$$\text{where } \bar{S}_{p2} = \frac{\bar{q}_r^2}{2b_r}$$

$$(2.16a)\quad E(S_g) = \bar{S}_{g1} + \frac{b_g\sigma_{DDg} - (b_g + 2a_g)\sigma_{SSg}}{2(a_g + b_g)^2} \quad \text{if } B_g \geq 0$$

$$\text{where } \bar{S}_{g1} = \frac{\bar{q}_g - B_g^2}{2b_g}$$

$$(2.16b)\quad E(S_g) = \bar{S}_{g2} + \frac{a_g^2\sigma_{SSg} + b_g^2\sigma_{DDg}}{2b_g(a_g + b_g)^2} \quad \text{if } B_g < 0$$

$$\text{where } \bar{S}_{g2} = \frac{\bar{q}_g}{2b_g}$$

$$(2.17a)\quad E(S_m) = (\bar{S}_{p1} - \bar{S}_{g1}) + \frac{b_r\sigma_{DDr} - (b_r + 2a_r)\sigma_{SSr}}{2(a_r + b_r)^2}$$

$$+ \frac{(b_g + 2a_g)\sigma_{SSg} - b_g\sigma_{DDg}}{2(a_g + b_g)^2} \quad \text{if } B_r, B_g \geq 0$$

$$(2.17b)\quad E(S_m) = (\bar{S}_{p1} - \bar{S}_{g2}) + \frac{b_r\sigma_{DDr} - (b_r + 2a_r)\sigma_{SSr}}{2(a_r + b_r)^2}$$

$$+ \frac{-a_g^2\sigma_{SSg} - b_g^2\sigma_{DDg}}{2b_g(a_g + b_g)^2} \quad \text{if } B_r \geq 0 > B_g$$

$$(2.17c)\quad E(S_m) = (\bar{S}_{p2} - \bar{S}_{g1}) + \frac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2b_r(a_r + b_r)^2}$$

$$+ \frac{(b_g + 2a_g)\sigma_{SSg} - b_g\sigma_{DDg}}{2(a_g + b_g)^2} \quad \text{if } B_g \geq 0 > B_r$$

$$(2.17d)\quad E(S_m) = (\bar{S}_{p2} - \bar{S}_{g2}) + \frac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2b_r(a_r + b_r)^2}$$

$$+ \frac{-a_g^2\sigma_{SSg} - b_g^2\sigma_{DDg}}{2b_g(a_g + b_g)^2} \quad \text{if } 0 > B_r,\ B_g$$

Price and Supply Stabilization

For the purposes of clarity, the following phrases are defined. Supply stabilization occurs whenever the variance component of the supply function σ_{SS}, decreases in value.[8] Price stabilization occurs when the variance of market (equilibrium) prices σ_{pp}, decreases in value.

If price fluctuations in the market are assumed to arise only from the stochastic elements associated with linear supply and demand functions, then from (2.7c) which is repeated here, one may observe that the variance in prices will be directly related to the demand and supply variances, but inversely related to the demand and supply slopes. Supply stabilization[9] schemes will always reduce but never eliminate price

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[8]Variation in supply may be reduced by withholding commodity from the market at times of above average supply by destroying or diverting part of the crop into storage and/or secondary markets (or both together), and at times of below average supply, releasing commodity from storage or relaxing tariff barriers.

[9]In agricultural product markets totally lacking in the wherewithal for storage of the commodity from season to season, the retail supply function becomes identical with the grower level supply function, both being perfectly inelastic. Introduction of supply stabilization schemes based on storage may generate externalities whereby the wherewithal for storage facilities is now gained by the marketing intermediaries to the

variability in the market. Price variability may be reduced to zero if the numerator $(\sigma_{DD} + \sigma_{SS})$ becomes zero, i.e., if both demand and supply functions are stabilized; or if the denominator becomes infinitely large, i.e., either the demand or supply function becomes infinitely elastic. This occurs whenever price floors (or ceilings) become operative.

$$(2.7c) \quad V(P_e) = \frac{\sigma_{DD} + \sigma_{SS}}{(a + b)^2}$$

Expression (2.7c) provides insights into market behavior. The price variability for many agricultural commodities will be large, in view of the fact that the demand for agricultural commodities is relatively stable[10] and inelastic, while the supply is inelastic but unstable.[11]

Market Intermediaries

The supply of agricultural produce at the grower level for any given season may be assumed to be perfectly inelastic. Since a perfectly inelastic grower supply function implies that the values of b_g and B_g will be zero and greater than zero respectively, expressions (2.17a) and (2.17c) become the appropriate expressions to use if the welfare of

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extent that some elasticity is introduced into the intraseasonsl supply function. Under such circumstances, the effect of supply stabilization schemes will not be the simple derivative but the total derivative of any function that includes both the supply variance σ_{SS} and the supply slope b as its arguments. For the purpose of this study it will be assumed that such externalities do not exist so that supply slopes will not be affected. The simple derivative then becomes appropriate for use when supply stabization schemes are evaluated.

[10]Stable in the sense that the stochastic element associated with the demand function is small. A time trend bias (such as the effect of increasing population) is not regarded as stochastic.

[11]Supply instability is largely due to weather in the case of perrenial crops; to acreage changes as well as weather in the case of annual crops; and the changing stock-flow decisions in the case of livestock.

market intermediaries in agriculture is to be considered. In both equations, it may be noted that middlemen welfare increases as the grower supply variance increases. Implementation of supply stabilization schemes to control fluctuations in grower supply will probably be opposed[12] by market intermediaries.

Given the wherewithal for storage of the agricultural produce, middlemen are able to be more responsive to price changes than growers. The slope of the retail supply function then will be more elastic. Withholding produce in anticipation of higher prices must, however, be offset by costs of storage and price undertainty. This implies that the increase in elasticity will be small, in which case b_r and B_r will be greater than zero. Thus only (2.17a) becomes the general welfare expression for market intermediaries in agriculture. For the convenience of the subsequent discussions, (2.17a) is reproduced below. From (2.17a), it may be observed that market intermediaries gain in welfare if they attempt to stabilize their supply at the retail level.

$$\text{(2.17a)} \quad E(S_m) = (\bar{S}_{pl} - \bar{S}_{gl}) + \frac{b_r\sigma_{DDr} - (b_r + 2a_r)\sigma_{SSr}}{2(a_r + b_r)^2} + \frac{(b_g + 2a_g)\sigma_{SSg} - b_g\sigma_{DDg}}{2(a_g + b_g)^2} \quad B_r,\ B_g \geq 0$$

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[12]This is not true for market intermediaries in industries with highly price responsive supply functions to the extent that B_g is less than zero. Under such circumstances, middlemen welfare will be defined by (2.17b) or (2.17d), in which case it will be to the advantage of market intermediaries to encourage (or even compensate) the primary producer to stabilize his supply.

Thus if market intermediaries can fully absorb grower supply instability to the extent that their retail supply is perfectly stable, they would have maximized[13] all the potential gains from the supply side of the marketing system.

The same expression provides additional insights into the market behavior of market intermediaries. Middlemen welfare increases as the retail (consumer) demand variance σ_{DDr} increases, but decreases as middlemen demand at the grower level σ_{DDg} increases.[14] If market intermediaries can fully absorb the retail demand variation to the extent that their grower level demand is perfectly stable, then market intermediaries have maximized all potential gains from the demand side of the marketing system.

Thus market intermediaries, acting so to speak, as a pair of shock-absorbers for the marketing system, perform such activities primarily to increase their welfare. This inference is not new in that such activities have been recognized as the sine qua non[15] of market intermediaries. Only the insights gained from (2.17a) are.

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[13]Storage makes such activity feasible. Actual gains in welfare would be reduced by the associated storage costs which are not considered in the above analysis. For a possible inclusion of storage costs into the framework, see Bieri and Schmitz (1974).

[14]This is true for all market intermediaries irrespective of the commodity handled since the statement holds for (2.17a) through (2.17d). This also helps to explain why marketing agents seek to open up new sources of demand, either by a change in product form or in the form of exports to foreign countries. Both the volume as well as the seasonal variation in demand is increased.

[15]Kaldor (1972, p. 1248) defines a market intermediary as one that is willing ". . . to absorb stocks in the face of excess supplies and to release stocks in the face of excess demand."

Consumers

The expression for consumer welfare as developed earlier, is given by (2.13). For the convenience of the discussion, it is reproduced below. From it one may observe that consumer welfare is directly related to the retail supply variance σ_{SSr}, as well as the retail demand variance $_{DDr}$. Market instability therefore, is always to the advantage of consumers.

$$(2.13) \quad E(S\ ) = \overline{S} + \frac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2a_r(a_r + b_r)^2}$$

If market intermediaries are totally successful in maximizing all potential gains from the supply side of the marketing system, the retail supply variance σ_{SSr} becomes zero in value. Under such circumstances, the implementation of supply stabilization schemes or even price stabilization schemes at the grower level will have no effect on consumer welfare; consumers will be indifferent to the implementation of supply or price stabilization schemes at the grower level.

In general, it would be unlikely that perfect stabilization of the retail supply function is achieved by market intermediaries. To the extent that perfect stabilization of retail supply is not achieved, consumer welfare will decrease whenever supply or price stabilization schemes are implemented at the grower level. However, with the tendency of market intermediaries to reduce retail supply variation to zero, it is highly probable that the decrease would be small relative to the total welfare accruing to consumers. Consumers then would be relatively indifferent to the implementation of supply or price stabilization schemes at the grower level.

From the discussion, it is clear that middlemen interests are

antagonistic to that of consumers. Any unit reduction in the variability of the retail supply function improves the welfare of market intermediaries by the amount[16] $[(b_r + 2a_r)/2(a_r + b_r)^2]$, but decreases that of consumers by[17] $[a_r/2(a_r + b_r)^2]$. Market intermediaries gain more than consumers loose. Society benefits in sum, and a compensation scheme may even be possible to offset the losses of consumers due to the marketing activity of market intermediaries. Thus while a state of conflict exists between consumers and marketing intermediaries, this conflict may be resolved to the satisfaction of both parties.

Primary Producers

The expression for primary producer (grower) welfare as developed earlier is given by (2.16a). This is the case when the supply function is relatively inelastic. Reproducing the same below for ease of referring, it may be observed that primary producers gain in welfare if they can stabilize their grower level supply. Supply stabilization at the grower level therefore will always be to the benefit of growers. Such schemes will always be supported by primary producers.

$$\text{(2.16a)} \quad E(S_g) = \bar{S}_{gl} + \frac{b_g\sigma_{DDg} - (b_g + 2a_g)\sigma_{SSg}}{2(a_g + b_g)^2} \quad \text{if } B_g \geq 0$$

From the expression, primary producer welfare increases as the variance of middlemen demand σ_{DDg} at grower level increases. Since it will be to the advantage of market intermediaries to stabilize their demand at the grower level, a state of conflict also exists between market intermediaries and primary producers. Unlike the case of the consumer/market

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[16]The partial derivative of (2.17a) with respect to σ_{SSr}.

[17]The partial derivative of (2.13) with respect to σ_{SSr}.

intermediary confrontation which is a positive sum activity, the confrontation of market intermediaries and primary producers is a zero sum activity. No net gain to society occurs so that no compensating scheme may be introduced. Thus the conflict between market intermediaries and primary producers is at a higher[18] level than that between consumers and marketing intermediaries.

It is only in the special[19] case when primary supply functions are perfectly inelastic (b_g is equal to zero) that the variance of middlemen demand becomes irrelevant to the welfare considerations for the two parties. When b_g is zero, no state of conflict will exist between the two parties.

Given that primary producers have a perfectly inelastic supply function, the only concern then of agricultural producers will be to stabilize supply, or alternatively, press for price stabilization. In the eyes of primary producers, the effect of either[20] will be identical. The effect of price or supply stabilization at the grower level as viewed by market intermediaries will also be the same. Both will reduce market intermediary welfare by the same amount--$(\frac{\sigma_{SSg}}{a_g})$. Market intermediaries in agriculture will oppose the implementation of supply or price stabilization schemes to the same degree.

The zero sum conflict between market intermediaries and primary

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[18]This may help explain why producer cooperatives number more than consumer cooperatives.

[19]Special only within the context of the discussion. Perfectly inelastic supply functions at the grower level is generally characteristic of agricultural production.

[20]This may explain why primary producers in agriculture have not tried to distinguish between supply and price stabilization schemes.

producers will not occur in vertically integrated grower cooperatives. Vertically integrated grower cooperatives will therefore remain indifferent to the implementation of supply or price stabilization schemes at the grower level.

Society

With the confrontation between market intermediaries and consumers a positive sum activity, and that between market intermediaries and primary producers (if and when the confrontation exists) a zero sum activity, the existence of market intermediaries will be to the benefit of society. From (2.12a), the stochastic element associated with the welfare of society may be written as

$$\frac{b_r\sigma_{DDr} - a_r\sigma_{SSr}}{2a_r(a_r + b_r)}$$

In the absence of market intermediaries, the retail supply variance σ_{SSr} becomes synonymous with grower supply variance σ_{SSg}. Since market intermediaries tend to absorb the grower supply variance in order to increase their own welfare, σ_{SSr} becomes very much less then σ_{SSg}. If market intermediaries are successful in absorbing all the grower supply variance to the extent that the retail supply variance is practically zero, then the implementation of supply stabilization schemes will not improve the welfare of society. It is only when market intermediaries are not fully successful in absorbing all the grower supply variation that supply stabilization schemes improve the welfare of society.

Price stabilization reduces the stochastic element associated with welfare of society to zero. In general then, as supply stabilization achemes always result in a net positive addition to the non-stochastic

term of the welfare to society, supply stabilization schemes will always be better[21] for society than price stabilization schemes.

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[21]Costs of administration of both schemes are assumed to be the same.

CHAPTER III
SUPPLY STABILIZATION AND NET WELFARE GAINS IN THE FLORIDA FCOJ INDUSTRY

The marketing system for Florida FCOJ may be characterized as a three-tiered system, the market levels being those at the grower level, the processor (wholesale) level, and the retail level. Figure 7 was modified by the addition of a processor (wholesale) market level to Figure 8. From Figure 8, the welfare of the four market participants in the FCOJ industry, namely consumers, retailers, processors, and growers, would be given by the areas denoted by S_c, $(S_p - S_w)$, $(S_w - S_g)$, and S_g respectively. If the supply and demand functions for the three market levels are described by the expressions (3.1a) through (3.1f), the equivalent welfare expressions for the four market participants may be written as (3.2a) through (3.2d) respectively. These welfare expressions are based on those developed earlier in Chapter II. Expression (3.2a) is identical to (2.13), and (3.2d) is identical to (2.16a). Expressions (3.2b) and (3.2c), the welfare expressions for the middlemen of the FCOJ industry--the retailers and the processors--were obtained from the total middlemen welfare function (2.17a) with suitable adjustments to the subscripts of the parameters to denote the additional market level that exists between the two market intermediaries.[1]

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[1]The sum of (3.2b) and (3.2c), the welfare expressions for the retailers and processors, gives (2.17a) the total middlemen welfare expression.

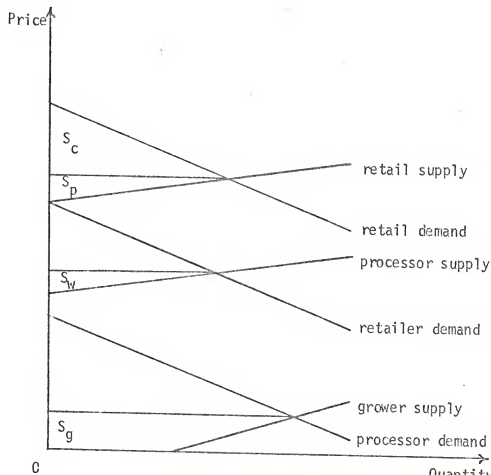

Figure 8.--Surplus due to consumers (S_c), all producers (S_p), processors and growers (S_w), and growers only (S_g)

(3.1a) retail demand: $Q_r^D = A_r - a_r P_r + u_r$

(3.1b) retail supply: $Q_r^S = B_r + b_r P_r + v_r$

(3.1c) retailer demand: $Q_p^D = A_p - a_p P_p + u_p$

(3.1d) processor supply: $Q_p^S = B_p + b_p P_p + v_p$

(3.1e) processor demand: $Q_g^D = A_g - a_g P_g + u_g$

(3.1f) grower supply: $Q_g^S = B_g + b_g P_g + v_g$

where Q_i^D = quantity of FCOJ demanded at the ith market level; $i = r$ denotes the retail level; $i = p$ denotes the processor level; $i = g$ denotes the grower level.

Q_i^S = quantity of FCOJ supplied at the ith market level.

u_i = error term associated with the demand function at the ith market level.

v_i = error term associated with the supply function at the ith market level.

(3.2a) consumer welfare: $E(S_c) = \bar{S}_c + \dfrac{a_r^2\sigma_{SSr} + b_r^2\sigma_{DDr}}{2a_r(a_r + b_r)^2}$

(3.2b) retailer welfare:

$$E(S_r) = (\bar{S}_{pl} - \bar{S}_{wl}) + \frac{b_r\sigma_{DDr} - (b_r + 2a_r)\sigma_{SSr}}{2(a_r + b_r)^2}$$

$$+ \frac{(b_p + 2a_p)\sigma_{SSp} - b_p\sigma_{DDp}}{2(a_p + b_p)^2} \quad \text{if } B_r, B_p \geq 0$$

(3.2c) processor welfare:

$$E(S_w) = (\bar{S}_{wl} - \bar{S}_{gl}) + \frac{b_p\sigma_{DDp} - (b_p + 2a_p)\sigma_{SSp}}{2(a_p + b_p)^2}$$

$$+ \frac{(b_g + 2a_g)\sigma_{SSg} - b_g\sigma_{DDg}}{2(a_g + b_g)^2} \quad \text{if } B_p, B_g \geq 0$$

(3.2d) grower welfare:

$$E(S_g) = \bar{S}_{gl} + \frac{b_g\sigma_{DDg} - (b_g + 2a_g)\sigma_{SSg}}{2(a_g + b_g)^2} \quad \text{if } B_g \geq 0$$

where σ_{DDi} = variance of error term u_i associated with the demand function at the ith market level

σ_{SSi} = variance of the error term v_i associated with the supply function at the ith market level

$$\bar{S}_{pl} = \frac{\bar{q}_r^2 - B_r^2}{2b_r} \; ; \; \bar{q}_r = \text{mean of } Q_r^S$$

$$\bar{S}_{wl} = \frac{\bar{q}_p - B_p^2}{2b_p} \; ; \; \bar{q}_p = \text{mean of } Q_p^S$$

$$\bar{S}_{gl} = \frac{\bar{q}_g - B_g^2}{2b_g} \; ; \; \bar{q}_g = \text{mean of } Q_g^S$$

Supply Stabilization

It was defined earlier in Chapter II that supply stabilization implies a reduction in the variance component of the supply functions. A perfectly successful supply stabilization scheme, for example, may be defined as one that reduces the supply variance at all three market levels in the FCOJ industry to zero, i.e., $\sigma_{SSg} = \sigma_{SSp} = \sigma_{SSg} = 0$.

With the implementation of the FCOJ reserve pool, fluctuations in the supply functions at the three market levels would be reduced, if not completely eliminated. As the net change in the market demand and supply functions would only be in the variance component of the supply functions,[2] the net change in the welfare position of consumers, retailers, processors,

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[2]It was assumed in this study that demand behavior at all three market levels would not change as a result of the existence of the FCOJ reserve pool.

and growers would relate only to the portion of the welfare expressions with the supply variance components, being σ_{SSr}, σ_{SSp}, and σ_{SSg}. The net change in the welfare of the market participants subsequent to the implementation of the FCOJ reserve pool were extracted from the expressions (3.2a) through (3.2d) to give (3.3a) through (3.3d).

(3.3a) net change in consumer welfare:

$$\Delta E(S_c) = \frac{-a_r (\sigma_{SSr1} - \sigma_{SSr2})}{2(a_r + b_r)^2}$$

(3.3b) net change in retailer welfare:

$$\Delta E(S_r) = \frac{(b_r + 2a_r)(\sigma_{SSr1} - \sigma_{SSr2})}{2(a_r + b_r)^2} - \frac{(b_p + 2a_p)(\sigma_{SSp1} - \sigma_{SSp2})}{2(a_p + b_p)^2}$$

(3.3c) net change in processor (wholesaler) welfare:

$$\Delta E(S_w) = \frac{(b_p + 2a_p)(\sigma_{SSp1} - \sigma_{SSp2})}{2(a_p + b_p)^2} - \frac{(b_g + 2a_g)(\sigma_{SSg1} - \sigma_{SSg2})}{2(a_g + b_g)^2}$$

(3.3d) net change in grower welfare:

$$\Delta E(S_g) = \frac{(b_g + 2a_g)(\sigma_{SSg1} - \sigma_{SSg2})}{2(a_g + b_g)^2}$$

where σ_{SSij} = variance of the supply function at the ith market level; j = 1 denotes the time period before the implementation of the FCOJ reserve pool, j = 2 denotes the time period subsequent to the implementation of the FCOJ reserve pool

Evaluation of the net welfare position of the four market participants subsequent to the implementation of the FCOJ reserve pool would be

possible if one could obtain estimates of the six quantity-price slopes for the three pairs of supply and demand functions, as well as the estimates of the variance component for each of the supply functions at the three market levels before and after the implementation of the FCOJ reserve pool. If prior research on the FCOJ industry could provide a complete set of these desired estimates, no estimation need be undertaken in this study.[3] The following section reviews the available estimates.

Prior Research on Parameter Estimates

Many studies have been carried out to determine the response of consumers to changing prices of FCOJ, as evidenced by those of Godwin and Powell (1957), Henderson (1965), Langham (1966), Weisenborn (1968), Myers (1969), and Myers and Liverpool (1972). Apart from the study of

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[3]Twelve estimates were required, six for the quantity-price slopes of the three pairs of supply and demand functions, three for the variance estimates of the existing supply functions and three for the variance estimates of the supply functions subsequent to the implementation of the Florida FCOJ reserve pool. If it is assumed that the derived demand functions--the processor demand as well as the retailer demand--have the same quantity-price slope as the consumer (retail) demand function, i.e., $a_r = a_p = a_g$, failure to obtain numerical estimates of any two of the three need not prevent the evaluation process. On a priori grounds, the grower supply function may be assumed to be perfectly inelastic due to the seasonal nature of the orange crop so that b_g will be equal to zero. If it is also assumed that the retailer supply have the same quantity-price slope as the processor supply function, failure to obtain estimates of either of the two again will not deter the evaluation of the net welfare effects of the implementation of the Florida reserve pool. With the additional assumption that the reserve pool will reduce all the supply variances to zero, i.e., $\sigma_{SSr2} = \sigma_{SSp2} = \sigma_{SSg2} = 0$, the number of estimates required may be reduced from twelve to five, being

i) σ_{SSr1} iv) any of a_r, a_p, or a_g ($a_r = a_p = a_g$)

ii) σ_{SSp1} v) either b_p or b_r ($b_p = b_r$)

iii) σ_{SSg1}

Langham which also attempted to determine the processor demand function for FCOJ, the following supply and demand functions at the three market levels have not been investigated: processor demand, grower supply, processor (wholesaler) supply, and retail supply. As the latter functions have not been investigated, it was clear that the complete set of estimates required may not be obtained from prior research.

The retail demand study of Myers and Liverpool gave a price elasticity of demand of -0.706. From the estimate, the quantity-price slope a_r was calculated[4] to be -0.0874 using a price-quantity ratio[5] of (4.018/0.4976). The study of the processor demand function at the grower level by Langham made use of rapidly changing supply conditions during freeze years. With rapidly changing supply, the processor demand function becomes identified. Using prices as the determined variable and quantity as the predetermined variable, the processor demand functions for the freeze years, 1957-58 and 1963-64, were estimated. Estimates from the 1957-58 season made no economic sense but a price flexibility estimate of -2.30 was obtained for the first half of the season, and -1.77 for the second half of the season were obtained for the 1963-64 season. Using a price flexibility for the entire season as the average of the two, i.e., -2.035, a quantity-price slope of -0.1842 was calculated[6] for a_g from a

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[4]The quantity-price slope obtained by Myers and Liverpool was not directly suitable because the function was estimated in natural logarithmic form.

[5]The values represent the average retail price per gallon for FCOJ in dollars for the seasons 1959-60 through 1973-74, deflated by the food price index, and the average per capita consumption of FCOJ, in gallons, for the same time span.

[6]The quantity-price slope as estimated by Langham was not suitable as the function was estimated using quantities in thousand boxes of oranges per month, rather than in gallons FCOJ per capita per annum.

price-quantity ratio[7] of (1.422/0.5329). These two slope estimates provide some basis for comparing the equivalent estimates obtained from the estimation techniques that were employed to provide the set of twelve estimates required for this study, namely a_r, a_p, a_g, b_r, b_p, b_g, σ_{SSr1}, σ_{SSp1}, σ_{SSg1}, σ_{SSr2}, σ_{SSp2}, and σ_{SSg2}.

The Model

Estimates of the parameters of the supply and demand functions given in (3.1a) through (3.1f) were required to evaluate the welfare expressions (3.2a) through (3.2d).

Statistical considerations prevent the direct estimation of the supply and demand functions in the simple linear two-variable form given by (3.1a) through (3.1f). Firstly, should shift variables be excluded from any of the functions, the estimates may suffer a specification bias. Secondly, if the functions were estimated by any direct (single stage) estimation process such as the ordinary least squares (OLS) technique, the estimated parameters may carry a simultaniety bias. Thirdly, even if one is willing to carry out a simultaneous estimation technique on the expressions, the equations may not be identified. For these reasons the six functions were not estimated in the algebriac forms (3.1a) through (3.1f) as expressed, but in the algebriac forms given by (3.4a) through (3.4f). Modifications on the supply and demand functions from (3.1) to (3.4) were based on a priori knowledge of the marketing system for FCOJ.

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[7]The values represent the average on-tree price per gallon equivalent of FCOJ received by growers, in dollars, for the seasons 1959-60 through 1973-74, deflated by the food price index, and the average per capita pack, in gallons, for the same time period.

(3.4a) retail demand

$$Q^D_{rt} = \alpha_{0r} + \alpha_{1t}P_{rt} + \alpha_{2r}PFCOS + \alpha_{3r}PDICPI_t + U_{rt}$$

(3.4b) retail supply

$$P_{rt} = \beta_{0r} + \beta_{1r}Q^S_{rt} + \beta_{2r}TA_t + \beta_{3r}P_{p,\ t-1} + \beta_{4r}P_{p,\ t-2} + \beta_{5r}C_t + V_{rt}$$

(3.4c) retailer demand

$$Q^D_{pt} = \alpha_{0p} + \alpha_1 P_{pt} + \alpha_{2p}PFCOS_t + \alpha_{3p}PDICPI_t + U_{pt}$$

(3.4d) processor supply

$$P_{pt} = \beta_{0p} + \beta_{1p}Q^S_{pt} + \beta_{2p}TA_t + \beta_{3p}P_{p,\ t-1} + \beta_{4p}P_{p,\ t-2} + \beta_{5p}C_t + V_{pt}$$

(3.4e) processor demand

$$P_{gt} = \alpha_{0g} + \alpha_{1g}Q^S_{gt} + \alpha_{2g}PFCOS_t + \alpha_{3g}PDICPI_t + U_{gt}$$

(3.4f) grower supply

$$Q^S_{gt} = \overline{Q}_g + V_{gt}$$

where Q^D_{it} = FCOJ demanded at the ith market level during season t, in gallons per capita

Q^S_{it} = FCOJ supplied at the ith market level during season t, in gallons per capita

$\overline{Q}_g$ = average annual pack of FCOJ, in gallons per capita per season

P_{it} = average price per gallon FCOJ at the ith market level during season t, in dollars, deflated by the food price index

$PFCOS_t$ = average price per gallon frozen concentrate orange synthetic during season t, in dollars, deflated by the food price index

$PDICPI_t$ = average per capita disposable income during season t, in thousand dollars, deflated by the consumer price index

TA_t = total gallons of FCOJ per capita available to the processors during season t

C_t = warehousing costs per gallon of FCOJ during season t, in cents, deflated by the wholesale price index

U_{it} = error term associated with the demand function at the ith market level

V_{it} = error term associated with the supply function at the ith market level

Primary (Grower) Supply

The orange crop for any given season may be regarded as a constant, independent of price. With the annual utilization of oranges in the non-FCOJ markets assumed to be constant in so far as this study is concerned, the annual supply of oranges for the FCOJ market, in gallon equivalents (the total annual pack) may also be regarded as being perfectly inelastic with respect to price; similarly the annual per capita pack. The annual per capita pack of FCOJ may be written as (3.4f).

Processor (Wholesale) Supply

The nature of the marketing system for FCOJ is such that Florida processors have control,[8] at least initially, over all the FCOJ available

[8]This control is not due to the purchase of ownership rights to the oranges to be processed into FCOJ by processors. In practice, processors act only as the agents of growers to process, inventory, and sell the FCOJ. They pass on to growers all returns less the costs associated with the services involved. On-tree prices are deferred and only finally determined upon sale of the FCOJ to retailers. Processors are not totally free from financial risks as they do own a portion of the FCOJ themselves. For the 1973-74 season, about 19.5 percent of the oranges processed into FCOJ were purchased by processors upon delivery on a price determined basis.

for subsequent sale in the retail market in the United States. The rate at which the FCOJ is disposed of at the processor level depends, in part, on the decisions made by processors. With the ability to store[9] FCOJ in frozen form and hence to carry it over from one market period to another, processors are given some degree of flexibility in making their decisions. This implies that the supply function of FCOJ at the processor level is more elastic than that at the grower level.

Processors control the rate at which FCOJ is sold to retailers by adjusting their quoted FOB prices for FCOJ. The exact mechanism with which the processors use to arrive at their price quotes is unknown. It was hypothesized that the pricing mechanism of processors takes into consideration the strength of the product movement and the total availability of FCOJ above and beyond a desired quantity that is to be held in inventory. The later quantity was not assumed to be constant, but to change with changes in the relative values of expectations of future prices vis a vis present prices and inventory costs. Writing the same in functional form, expressions (3.5a) and (3.5b) were obtained. It was further assumed that price expectations for future market periods is some function of present and past prices. If the number of lagged prices is restricted to two, one obtains expression (3.5c).

(3.5a) $P_{pt} = P(Q_{pt}, TA_t, Invent^*_t, e_{1pt})$

where P_{pt} = FOB price per gallon of FCOJ at the processor level for season t, in dollars, deflated by the food price index

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[9]Strictly speaking, not all FCOJ inventoried at the end of any market period, is carried over purely as a deferred supply activity. Some amount is carried over for blending purposes to produce a more homogenous and desirable product.

Q^s_{pt} = gallons FCOJ per capita sold by processors during season t

TA_t = total gallons FCOJ per capita available during season t

$Invent^*_t$ = a desired per capita inventory level for FCOJ to be held during season t, in gallons

e_{1pt} = error term

(3.5b) $Invent^*_t = i(P^*_{p,\ t+1}, P_{pt}, C_t, e_{2pt})$

where $P^*_{p,\ t+1}$ = the expected FOB price per gallon of FCOJ during season (t + 1) at the processor level, in dollars

C_t = present warehousing costs per gallon of FCOJ, in cents, deflated by the wholesale price index

e_{2pt} = error term

(3.5c) $P^*_{p,\ t+1} = p^1(P_{pt}, P_{p,\ t-1}, P_{p,\ t-2}, e_{3pt})$

where e_{3pt} = error term

Substituting (3.5b) and (3.5c) into (3.5a) and writing the resultant in linear additive form gives (3.4d), the processor supply function. From a priori grounds, the signs associated with the coefficients for the quantity supplied and total availability variables will be expected to be positive and negative, respectively.

Retail Supply

As retailers release FCOJ to consumers on the basis of a retail price mark-up, the supply function of retailers would depend on the supply function of processors. All shift variables found in the processor supply function must necessarily be expressed in the retail supply function. The retail supply function may be written as (3.4b). This is

basically identical to the processor supply function (3.4d) but for appropriate changes in the subscripts of the coefficients.[10]

The retail supply function is not influenced by the level of retail inventory because of the nature of the marketing system. At times of demand weakness at the retail level, price reductions in FCOJ at the retail level are not mainly borne by retailers but by processors (and thereby also growers, since processors act as their agents). When processors lower their prices at times of weakness in retail demand, prices of FCOJ sold to retailers in the previous three or even four weeks will also be reduced. Such rebates will be credited to the accounts of retailers by processors. At times of increasing retail demand, processors would increase their prices at the wholesale level, but retailers are offered a period of about two weeks of "buy in" time during which normal purchases may be billed at the previous (lower) price. Under such a marketing system, the holding of inventory by retailers for the purpose of speculation would merely tie up capital and increase associated costs of storage without any accompanying advantage.

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[10]The inclusion of shift variables from the processor supply function in the retailer supply function does not, however, preclude the existence of other shift variables in the retailer supply function. Inputs are required for retailer activities that add space and time utilities to the FCOJ product. The omission of these shift variables from the retail supply function introduces a specification bias on the intercept and variance estimates of expression (3.4b), if it is assumed that the predetermined variables in the same expression are uncorrelated with each and every excluded transfer cost variable; the bias for the variance estimate will be positive, and that for the intercept indeterminate. From a priori grounds, such an assumption would be true for all the predetermined variables except for the warehousing cost variable. It may be argued that warehousing costs are highly correlated with transfer cost variables since the input factors associated with warehousing activity would be the same as that for transportation, namely labor and energy costs. Under such a circumstance, the specification bias on the intercept and variance estimate is reduced. It will be eliminated entirely if the correlation of the warehousing cost variable and the excluded transfer cost variable is perfect.

Consumer (Retail) Demand

Recent studies on consumer demand for FCOJ in the United States have shown important demand shifters. Myers (1968) using multiple regression analysis on monthly data from January 1965 through December 1968, reported that per capita consumption of FCOJ is affected by consumer incomes as well as the prices of frozen concentrate orange synthetic. Myers and Liverpool (1972) using monthly data from January 1968 through April 1971 also[11] found the same although the model differed slightly from the earlier study of Myers by the incorporation of a summer shift (dummy) variable. Since population and consumer incomes change with time in processes that are not random, the retail demand function would not be adequately specified if consumer demand is defined as a function of price alone. Expressing the per capita consumer demand function in linear additive form we have (3.4a).

Retailer Demand (At Processor Level)

As retailer demand at the processor level is a reflection of the retail (consumer) demand, all shift variables that enter into the retail demand function must necessarily influence retailer demand too. The inclusion of all the shift variables associated with the retail demand function into the retailer demand function at the processor level does not preclude the existence of additional shift variables in the retailer

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[11]Variables in both the multiple linear regression analyses were in natural logarithms. The OLS estimation technique was used. The effect of price from chilled orange drink was also found to affect consumer demand of FCOJ. Prices of chilled orange juice were not included in the present analysis of consumer demand for FCOJ because of the highly stable nature of consumer demand for non-FCOJ orange products. Supra p. 7.

demand. The relationship between the retailer demand and consumer demand is essentially the same as that between processor supply and retailer supply discussed earlier. Similarly, the retailer demand function at the processor level must include all the shift variables found in the consumer demand function. With appropriate changes to the subscripts of (3.4a), the retailer demand at the processor level may be given by (3.4c).

Processor (On-tree) Demand

With the short run supply of oranges from growers being perfectly inelastic, but shifting annually due to changes in weather as well as to long run (trend) effects of changing acreage, tree number, density, and age, the processor demand at the grower level in per capita FCOJ gallon equivalents may be estimated if the variables that affect the processor demand function are defined. As processor demand at the grower level is itself a derived demand stemming from the retailer demand at the processor level, all the shift variables found in the retailer demand function must necessarily be included in the processor demand function. The on-tree processor demand may therefore, be written as (3.4e).

Structural Change in the FCOJ Industry

Beginning with the 1965-66 season, FCOJ retailed in the domestic markets of the United States has been of 45 degrees Brix.[12] For earlier

[12]Oranges produced by growers are sold to processors on the basis of the amount of pounds solids per 90 pound box of oranges, as determined from a sample. The 'solids' would be the residue from the expressed juice upon the removal of water. One measure of the total solids content in a solution is the 'degrees Brix.' This is used by the industry to determine the solids content per gallon of FCOJ. An equivalence of 4.5 pounds of solids per gallon to a measure of 45 degrees Brix may be taken as a rule of thumb.

years, a 42 degree Brix product was retailed. The effect of this product change on the FCOJ industry (if any) may be adjusted for by the inclusion of a shift (dummy) variable for all the behavioral functions discussed earlier. This will be for all the demand and supply functions except the primary (grower) supply, i.e., expressions (3.4a) through (3.4e) will include an additional shift variable.

Statistical Considerations

If the endogenous variables and predetermined variables in expressions (3.4a) through (3.4e) are grouped, the five equation set may be written in matrix form as (3.6).

$$(3.6) \quad By_t + \Gamma x_t = u_t$$

where

$$y_t = \begin{bmatrix} Q_{rt} \\ P_{rt} \\ Q_{pt} \\ P_{pt} \\ P_{gt} \end{bmatrix}_{(5\times 1)}, \quad x_t = \begin{bmatrix} 1 \\ PFCOS_t \\ PDICPI_t \\ TA_t \\ P_{p,\,t-1} \\ P_{p,\,t-2} \\ C_t \\ Q_{gt} \\ D \end{bmatrix}_{(9\times 1)}, \quad u_t = \begin{bmatrix} u_{1rt} \\ u_{2rt} \\ u_{1pt} \\ u_{2pt} \\ u_{gt} \end{bmatrix}_{(5\times 1)}$$

Minimum standards have been set for the product by the United States Department of Agriculture (USDA) as well as by the state of Florida. Florida's standards are generally higher than that of the USDA. It requires that the Brix rating for FCOJ retailed in the United States and Canadian markets be not less than 44.8 degrees Brix; a ratio of Brix to acids content of less than 19 to one but more than 12 to one; and a score rating of more than 94. (Score is the composite rating for color, flavor, and defects.)

D is a zero-one variable introduced to allow for any intercept shift as a consequence of the 1965-66 change in the required degrees Brix of FCOJ. It is zero prior to the 1965-66 season and one subsequent to that date, inclusive.

$$B = \begin{bmatrix} 1 & \beta_{r2} & 0 & 0 & 0 \\ \beta_{r1} & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & \beta_{p2} & 0 \\ 0 & 0 & \beta_{p1} & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (5\times5)$$

$$\Gamma = \begin{bmatrix} \gamma_{1r1} & \gamma_{1r2} & \gamma_{1r3} & 0 & 0 & 0 & 0 & 0 & \gamma_{1r9} \\ \gamma_{2r1} & 0 & 0 & \gamma_{2r4} & \gamma_{2r5} & \gamma_{2r6} & \gamma_{2r7} & 0 & \gamma_{2r9} \\ \gamma_{1p1} & \gamma_{1p2} & \gamma_{1p3} & 0 & 0 & 0 & 0 & 0 & \gamma_{1p9} \\ \gamma_{2p1} & 0 & 0 & \gamma_{2p4} & \gamma_{2p5} & \gamma_{2p6} & \gamma_{2p7} & 0 & \gamma_{2p9} \\ \gamma_{g1} & \gamma_{g2} & \gamma_{g3} & 0 & 0 & 0 & 0 & \gamma_{g8} & \gamma_{g9} \end{bmatrix} \quad (5\times9)$$

The assumptions that are consistent with the earlier discussions will be the following:

Zero mean and normality

$u_t \sim N(0, \Phi)$, where 0 is a column vector of zeros, and Φ the variance-covariance matrix of the structural disturbances, i.e., $\Phi = E(u_t u_t')$;

Non-autocorrelatedness

$E(u_t u_s') = 0$; $t, s = 1, \ldots T$, where T is the total number of observations and $t \neq s$;

x matrix

The rank of x is $9 < T$, and $\text{plim}\ (\frac{1}{T}x'x) = \Sigma_{xx}$, where the contemporaneous covariance matrix Σ_{xx} is non-singular.

From (3.6), it may be observed that the order (necessary) conditions for the identification of the structural equations are satisfied.[13] The supply and demand functions for the retail and processor levels are over-identified. The identification considerations need not apply to the demand function at the grower level since the direction of causality is clear.

It is apparent that matrix B is block-diagonal. If the corresponding variance-covariance matrix of structural disturbances associated with matrix B is also block-diagonal, then three separate systems are actually operative. From the earlier discussions, however, the disturbances are believed not to be block diagonal. What results is a "seemingly" unrelated system set.[14]

A full system method such as the three stage least squares (3SLS) would be most appropriate on theoretical grounds. In addition to the 3SLS procedure which would allow for the related disturbances, two stage least squares (2SLS) and the ordinary least squares (OLS) estimation techniques were also applied. OLS was used because no information on the extent of the simultaniety bias is available. In practice, the bias may even be negligible relative to the standard error of the estimated parameter that is free from such a bias.

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[13]An equation is identified as per the order condition if the number of predetermined variables excluded from the equation but included in the system is greater than or equal to the number of endogenous variables in the equation, less one. This means that structural estimates may be obtained, provided the total number of observations must exceed the number of predetermined variables plus one.

[14]Since markets at different levels affect each other, it is obvious that a relationship must exist amongst the grower, processor, and retail market levels.

The Data

While the harvesting of Florida citrus begins in October, no significant amount of FCOJ is processed until December. Processing continues until harvesting is completed, usually in July. Processed shipments are made year round. All weighted annual average prices for FCOJ as well as for the prices of the frozen concentrate orange synthetic will be weighted averages calculated for the months of December through November of the following year.

Total Availability and the Amount of FCOJ Sold

The amount of FCOJ available for sale to retailers in the United States domestic markets was obtained by adding both the carryover from the previous season as well as imports to the annual pack, and subtracting from the resultant the quantity exported or sold to the U. S. government.[15] The amount of carryover, imports, annual pack, exports, and U. S. government purchases were reported by The Florida Canners Association (1974). The amount of FCOJ exported from Florida was used. For the 1964-65 and earlier seasons, such information was not available in that it was not separated out from the listing of total U. S. exports. It was assumed that for the 1964-65 and all earlier seasons, the total U. S. export of FCOJ was entirely of FCOJ from Florida.

Subtracting from the total availability the amount going into inventory as carryover for the next season gave the amount of FCOJ sold by processors to retailers at the wholesale level.

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[15]This will be purchases for the military and school lunch programs. Implicit in the subtraction process is the assumption that the amount of exports and purchases by the government are exogenous to the price determination process in the domestic markets of the United States.

Since the marketing system is such that retailers do not maintain an inventory for speculative purposes, the amount sold by processors was also assumed to be identical to the amount retailed to consumers in the same season.

Prices

All annual prices were weighted by the quantities involved. Weighted annual average prices in dollars for FCOJ at the processor (FOB) level per dozen six ounce can packs, and for FCOJ at retail (per six ounce can) were obtained from the Economic Research Department, The Florida Department of Citrus.[16] These prices were converted to dollars per gallon by using the relationship that a six ounce can is equivalent to (1.778/12) gallons. The weighted annual prices for frozen concentrate orange synthetic were also obtained from the same source.

On-tree prices (per box of oranges) were obtained by weighting the on-tree prices for processed round oranges and on-tree prices for processed Temples by the quantities involved. On-tree prices for round oranges and Temples, as well as the quantities processed (in boxes) of these two orange types were obtained from the Florida Crop and Livestock Reporting Service (1974).

One question associated with prices was whether prices should be adjusted by some price index. In a casual framework where price determines quantity or quantity determines price, only one party is involved.

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[16]FOB prices were the weighted annual average of non-advertised card prices circulated by Florida processors to their clients. Retail prices of FCOJ and FCOS were weighted prices and are based on consumer panel survey data involving 7.5 thousand households collected by the Market Research Corporation of America for the Florida Department of Citrus.

In a simultaneous framework, at least two parties are involved. A price index most appropriate for one is usually not suitable (from an a priori ground) for the other. The choice then was either to choose a single index with which to deflate all FCOJ prices or not to deflate the prices. It was decided to deflate the prices of FCOJ at the three market levels by the food price index. The prices of FCOS were similarly deflated by the same index.

Population, Price Indices, and Personal Disposable Income

The data series for these variables were obtained from the U. S. Department of Commerce (1974 and earlier issues). The population deemed appropriate is the population on July 1 for each season.

Warehousing Costs

The estimates made by Spurlock, Ward, and Sherrod (1974 and earlier issues) gave the data series through to the 1972-73 season. These values were obtained from an analysis of actual costs incurred by a survey of processing firms. For the 1973-74 season, the average cost of warehousing was assumed to follow the same proportionate increase in processing costs over the previous 1972-73 season as made by Lester (1974). Lester estimated an increased processing cost of 7.1 percent. Warehousing costs for FCOJ were deflated by the wholesale price index.

Period of Study

The period of study adopted was from the 1957-58 season through the 1973-74 season. The selection of the 1957-58 season was determined by two considerations, one being that observations too far back into time

should be avoided as far as possible and the other that some balance should be provided to the data set with respect to a possible change in structure. It was during the 1963-64 through the 1965-66 seasons that the Florida FCOJ industry saw the significant introduction of competing synthetic products. Simultaneously, the industry was involved in a change in product form, the Brix content of FCOJ being increased from 42 degrees to 45 degrees.

Statistical Results

Behavioral Functions

The results from the estimation techniques are summarized in Table 2. The marketing system for FCOJ as estimated appears to be well behaved in the sense that the estimates of the parameters did not change dramatically with a change in the estimation technique. Changes in the signs of the coefficients occurred for five parameters, two in the processor (wholesale) supply function, two in the retail supply function, and one in the processor demand function. In both the supply functions, the parameters involved were those for the intercepts and the lagged processor price. The sign change in the processor supply function was for the one period lagged processor price, while that for the retail supply the twice lagged processor price. In the case for the processor demand function, the change in sign involved that for the intercept term only. There is no a priori information on what the signs of these coefficients should be so no criteria exists for choosing one set of results over the others based on the sign changes.

Insofar as the price-quantity relationships for the five behavioral functions are concerned, the signs were as one would expect; positive slopes for the supply functions and negative slopes for the demand functions.

For a given estimation technique, with the exception of the lagged processor variable, all shift variables involved in the processor supply function also carried the same sign in the retail supply function. Similarly, all shift variables in the retail demand function carried the same signs in the retailer demand function, as well as in the on-tree processor demand function at the grower level.

Table 2.--Summary of statistical results for the FCOS markets[a]

Equation type	Estimation method	Endogenous variables				Predetermined variables							
R^2 D. W.[b]	V(residuals)	Q_r, Q_p	P_r	P_p	P_g	Constant	PFCOS	PMICPI	TA	$P_{p,\,t-1}$	$P_{p,\,t-2}$	C	Q_g	D
Retail demand	OLS	*	-0.06330			-0.1036	-0.1452	.3681						-0.08439
.96 2.73	.0006034		(.01491)			(.1690)	(.02647	(.05125)						(.03865)
	2SLS	*	-0.05938			-0.09857	-0.1408	.3610						-0.09127
	.0013490		(.01592)			(.1632)	(.02709)	(.05221)						(.03663)
	3SLS	*	-0.06812			-0.1515	-0.1460	.3778						-0.09169
	.0006463		(.01190)			(.1368)	(.02495)	(.04917)						(.03396)
Retail supply	OLS	3.273	*			6.869			- 5.269	-0.05829	-0.3120	.1811		-1.256
.91 2.21	.1438	(6.168)				(2.253)			(3.741)	(.2576)	(.1752)	(.1447)		(.3556)
	2SLS	16.56	*			3.291			- 13.17	.2096	-0.2812	.3531		-1.559
	.2968	(11.22)				(3.499)			(6.704)	(.3627)	(.2217)	(.2093)		(.4845)
	3SLS	27.58	*			-1.160			-18.95	.5398	-0.02935	.5133		-1.651
	.1759	(9.469)				(2.575)			(5.702)	(.3016)	(.1691)	(.1845)		(.4576)
Retailer demand	OLS	*		-0.06854		-0.2367	-0.1558	.3975						-0.07346
.96 2.05	.0006436			(.01593)		(.1372)	(.02565	(.04990)						(.03629)
	2SLS	*		-0.07467		-0.2066	-0.1626	.3938						-0.07036
	.0008614			(.01737)		(.1420)	(.02626)	(.05045						(.03564)
	3SLS	*		-0.06240		-0.2749	-0.1565	.4046						-0.07985
	.0005635			(.01319)		(.1273)	(.02485)	(.04876)						(.03363)
Processor supply	OLS	4.573			*	4.504			- 5.267	-0.06489	-0.2617	.2066		-0.9783
.91 2.07	.1428	(6.059)				(2.002)			(3.635)	(.2517)	(.1712)	(.1414)		(.3772)
	2SLS	18.07			*	1.294			-13.22	.2047	-0.2206	.3297		-1.284
	.2311	(11.06)				(2.598)			(6.826)	(.3605)	(.2194)	(.2074)		(.4769)
	3SLS	24.15			*	-3.501			-19.14	.5416	.005984	.5422		-1.350
	.1720	(9.299)				(2.920)			(5.602)	(.2953)	(.1860)	(.1814)		(.4512)
Processor demand	OLS				*	.08370	-0.2134	1.459					-3.429	-1.113
.84 2.77	.1031					(1.312)	(.3276)	(.7154)					(.9646)	(.3539)
	2SLS				*	.03820	-0.2134	1.459					-3.429	-1.113
	.1031					(1.419)	(.3276)	(.7154)					(.9646)	(.3539)
	3SLS				*	.3066	-0.2859	1.759					-3.901	-1.171
	.1069					(1.294)	(.3028)	(.6447)					(.7590)	(3.317)

[a] R^2 = coefficient of determination; D. W. = Durbin Watson statistic; V(residuals) = variance of residuals; OLS = ordinary least squares; 2SLS = two-stage least squares; 3SLS = three-stage least squares; * = variable normalized on; ( ) = standard error of estimate.

[b] Since lagged prices appear among regressors, these statistics have little value as indicators of serial correlation.

Note: Input data used in the analysis are presented in Appendix A.

The negative sign for the structural change (dummy) variable in the retail demand function indicates that consumers tended to buy less FCOJ after the introduction of a higher quality product. Economic theory would suggest that with other things equal, demand would increase as a consequence of the quality improvement of the product and not decrease. The effect of the quality improvement was probably confounded with the factors that lead to the apparent decrease in demand which motivated the industry to improve the quality of its product and its advertising program. A less likely explanation would be that consumers could be reacting to the real concentrate content rather than to the apparent gallonage in their purchasing behavior. So even though the empirical evidence suggests a structural shift, the results provide no help in explaining its cause.

The structural shift of the supply function is an increasing rightward shift (in the traditional concept). Such a behavior is interesting, for an increase in product concentration involves more processing activity as well as more raw produce. Cost per unit product would be increased. This resulting increase in costs in normal circumstances would be reflected as a backward shift in the supply function. Here a positive rightward shift has occurred. This would indicate that a deliberate pricing change has been carried out by the FCOJ industry. The industry is charging less per unit of product than it did previously.[17] Such an activity may be the reaction of the FCOJ industry to the entry of synthetic orange beverages into the market. A classical market

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[17]It is possible to estimate the loss in welfare (revenue) to producers as a result of the entry of synthetic orange beverages into the market from the estimated behavioral equations. The difference in revenues to producers before and after both the demand and supply shifts would provide an estimate of the costs involved.

response to competition has occurred--the product quality was improved and the price decreased.

The negative sign for the price of the frozen concentrate synthetic product (FCOS) in all the demand functions may be rationalized as being the net effect of a structural change due to the entry of the product into the market as well as the normal price response. The structural change effect may swamp the (normally) positive price effect to give a negative net effect. No attempt was made to separate out the two in this analysis.[18]

The positive response of consumers to increases in income is in accordance with a priori considerations. The same applies to the signs[19] of total availability and warehousing costs.

The two-variable quantity-price relationships were obtained by substituting the mean values for all the variables (except the price and quantity variable) from Appendix Table A.5 into the estimated equations tabulated in Table 2.[20] In the case of the supply functions as well as the grower demand function, the inverse functions were obtained

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[18]It is difficult to introduce another dummy variable into the analysis to separate out the price and structural change effects due to the entry of FCOS into the market. The difficulty is statistical in nature. This new dummy variable will be very highly correlated with the dummy variable introduced for a product change, and would add problems with multicollinearity.

[19]Discussion of significance of structural coefficients may not be done separately, i.e., only in the context of the size of the estimated coefficient and its associated standard error. In the absence of a joint hypothesis, single "t" tests carried out result in an uncontrolled Type I error.

[20]This gives the intercept values so that the total welfare position of any market participant may be evaluated, if so desired. As evaluated, the intercepts will be for the means of the shift variables used in this study.

directly.[21] Table 3 summarizes the two-variable quantity-price relationships.

Choice of Estimation Technique

From Table 3, no major differences may be discerned amongst the OLS, 2SLS, and 3SLS estimation techniques. The simultaneity bias present in the OLS estimates appear to be relatively small, while not much gain in efficiency appears to be obtained from the GLS procedure.[22] It was decided that the estimates from the 2SLS would be used in calculating the net welfare positions of the market participants in the FCOJ market subsequent to the implementation of the reserve pool. Figure 9 illustrates the supply and demand relationships as obtained by the 2SLS technique.

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[21]Obtaining the inverse functions to provide the estimates of the desired parameters does not, of course, provide the same estimates as one would have obtained from a price determining relationship. The welfare equations developed earlier could just as well have been cast in a price dtermining framework, rather than in the price determined framework.

[22]The 3SLS estimation technique used the variance covariance matrix obtained from the 2SLS estimation process. It was not altered in any way. An attempt was made using a modified variance covariance matrix with the covariances between the residuals of supply and demand functions equal to zero, and then iterating on the parameters (with the variance covariance matrix held constant) till stability was achieved. After 20 iterations on the Time Series Processor (TSP) software package of the Harvard Institue of Economic Research, convergence was not obtained. Results from the 20th iteration did not make any sense (such as zero values for the standard errors of four coefficients).

Except for the above mentioned use of TSP, all computations were made using the Econometric Software Package (ESP) as developed by J. P. Cooper of the Graduate School of Business, University of Chicago. Computer facilities used were those of the North East Regional Data Center, Gainesville, Florida.

Table 3.--Quantity-price relationships for the FCOJ markets[a]

Equation type	Estimation method	Variance of residuals	Retail price	Wholesale price	On-tree price	Constant
			coefficients			
Retail demand	OLS	.0008334	-0.06330			.7519
	2SLS	.0008480	-0.06938			.7762
	3SLS	.0008463	-0.05812			.7310
Retail supply	OLS	.01390	.3055			-0.7300
	2SLS	.0008504	.05995			.2566
	3SLS	.0006256	.03626			.3519
Retailer demand	OLS	.0008488		-0.06854		.6983
	2SLS	.0008614		-0.07467		.7165
	3SLS	.0008630		-0.06240		.6804
Processor supply	OLS	.006795		.2187		-0.1431
	2SLS	.0007078		.05534		.3353
	3SLS	.0005567		.03431		.3972
Processor demand	OLS	.008768			-0.2916	.9474
	2SLS	.008768			-0.2916	.9474
	3SLS	.006998			-0.2563	.8970

[a]Normalized on per capita gallons FCOJ; all symbols are identical to those used in Table 2.

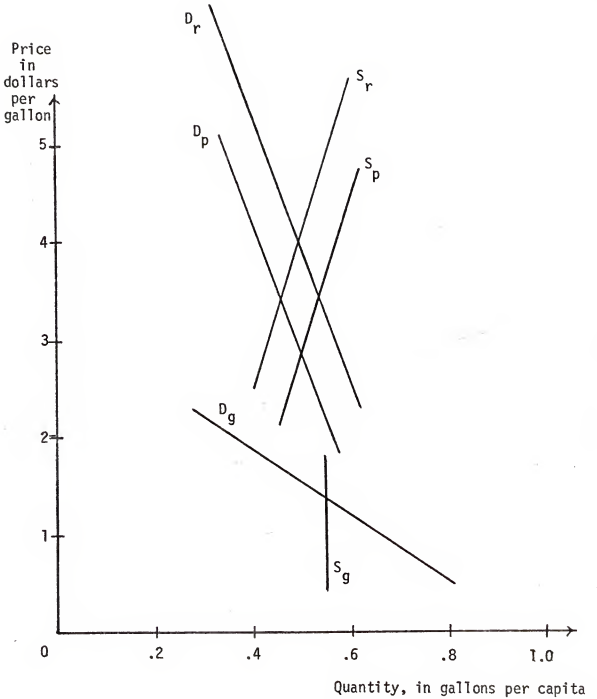

Figure 9.--Supply and demand relationships for the FCOJ markets

Welfare Considerations

The retail demand slope as obtained from the 2SLS estimation technique was -0.0694. This is greater than -0.0874, the slope calculated from the retail demand elasticity as estimated by Myers and Liverpool (1972) but not much different from that obtained from the study of Myers (1969) from which a slope of -0.0676 was calculated.[23] As for the processor demand slope, a value of -0.292 was obtained. This is much less than -0.184, the quantity price slope calculated from the Langham study. It may be probable then that the processor demand slope ($-a_g$) is underestimated.

An underestimate of the processor demand slope would lead to an underestimate of the net welfare gain that may accrue to growers subsequent to the implementation of the reserve pool, and an overestimate of the gains to processors.[24] Conversely, losses to processors due to the existence of the reserve pool is underestimated.

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[23]Myers obtained an elasticity of -0.546. With the same averages of retail price and quantity as used in this study, i.e., 4.018 and 0.4976 respectively, a quantity-price slope of -0.0676 was obtained.

[24]The relevant net welfare expressions to processors and growers as a result of the introduction of the FCOJ reserve pool are (3.3c) and (3.3d), more especially (3.3d) since (3.3d) is also the only component of (3.3c) involving the processor demand slope ($-a_g$). In this study where the annual grower supply of FCOJ is assumed to be perfectly inelastic, the value of the grower supply parameter b_g is zero. Expression (3.3d) simplified to

$$\frac{\sigma_{SSg1} - \sigma_{SSg2}}{a_g}$$

This expression is underestimated whenever the processor demand slope ($-a_g$) is underestimated. The welfare gains of growers and the welfare losses of processors would be underestimated.

Supply and Demand Variances

The variances of the supply and demand functions as developed for the welfare equations include the effects of shift variables. The variance of the residual terms from the 2SLS technique will not be the correct estimate of the desired variance components. If all shift variables in the estimated supply and demand functions are delegated to the error component, the new error component will be observed to be a linear combination of the shift variables as well as the residuals from the estimated equations.[25] Its variance can be computed directly. Table 4 summarizes the estimates of the variance components of the supply and demand functions that would be appropriate for the welfare equations.

The values of the variance estimates given in Table 4 are interesting. There is no appreciable change in the variance of the supply or demand functions between the retail and wholesale levels. Retailers are not behaving as active market intermediaries, but rather as passive market intermediaries. They do not absorb the variations in the supply and demand. This result was anticipated in that it is known that retailers do not carry speculative inventory. Processors are those that carry the speculative inventory. From the theoretical framework developed earlier, it would be expected that the variance of the processor supply function be much less than that of the grower supply function. This was observed to be the case. A reduction in the supply variance from 0.029 to 0.018

[25]As the structural change variable describes a once only change, this variable will not add any additional variation to the supply and demand functions in all years subsequent to the 1965-66 season. For this reason it was not included in the variance adjustments. As for the variance of FCOS, all zero values will be ignored in its determination. Appendix Table A.5 gives the standard deviations of all the shift variables from which their variances may be calculated.

Table 4.--Variance estimates of the supply and demand relationships for the FCOJ market[a]

Market level	Function type	
	Demand	Supply
	(gallons/capita)^2	
Retail	.01670	.02092
Wholesale	.01970	.01794
Grower	.03056	.02939

[a]As estimated from the 2SLS technique.

gallons per capita did occur. Also from the theoretical framework, it was expected that processors will not devote any effort to stabilizing their demand function since the grower supply function is perfectly inelastic. This proposition is supported by the evidence. The variance of the processor demand function actually increased over that of the retailer demand function.

Net Welfare from Perfect Stabilization

So long as the fundamental nature of the FCOJ markets remain unchanged, estimates of the net welfare positions of the market participants will be independent of time, at least on a per capita basis. Adjustments for changes in the intercept values of the functions due to changing values of the shift variables are not necessary since the net welfare expressions for the market participants as given by (3.3a) through (3.3d) do not require the values of the intercepts.

The net welfare positions of the market participants subsequent to the implementation of a perfectly successful supply stabilization scheme, defined earlier to imply that $\sigma_{SSr2} = \sigma_{SSp2} = \sigma_{SSg2} = 0$, may be evaluated by substituting the estimates of the quantity-price slopes from the 2SLS estimation procedure given in Table 3 and the corresponding variance estimates from Table 4 into the expressions (3.3a) through (3.3d). Table 5 summarizes the estimates obtained.

Table 5.--Net per capita welfare gains to the market participants of the U. S. domestic FCOJ market, with respect to perfect supply stabilization

Market participant	Net change, in dollars per capita × 10^{-3}
Consumers	-43.39
Retailers	15.64
Processors	7.83
Growers	100.78

[a]All estimates are based on the 2SLS estimation procedure. Perfect supply stabilization assumes that all supply variances are reduced to zero.

From Table 5, it may be observed that each and every market participant on the supply side will gain with the introduction of a perfectly successful supply stabilization scheme. As these gains were measured on

a per capita basis, the total gains would increase with time, if one allows for increases in the population with the passage of time. Of the total gain in welfare going to the market participants on the supply side, 81 percent will go to growers, 13 percent to retailers and 6 percent to processors. Processors will be the least interested in the implementation of a supply stabilization scheme.

Given that the population in the United States in 1974 was 212 million, the gains to growers for that year alone would have been 21.37 million dollars; that of retailers 3.32 million dollars; with 1.66 million dollars going to processors. Consumers would, of course, lose with supply stabilization. Their loss would amount to 9.20 million dollars had a supply stabilization scheme been implemented in 1974.[26]

Net Welfare from the Florida Reserve Pool

The welfare gains (losses) to the market participants as listed in Table 5 are the maximum gain position resulting from a total reduction of all supply variances to zero. As proposed, the reserve pool for Florida oranges only relates to the control of the movement of physical amounts of the product in FCOJ form, and no more. This control of the movements of the physical quantities of the product may reduce the variances of the supply functions only by the extent to which the actual availability of the product affects the supply relationships. The reserve pool cannot hope to control shifts in the supply functions caused by changes in market prices, or due to changes in costs of storage and warehousing. At

[26]The total U. S. domestic retail value for FCOJ in the 1973-74 season was 433.01 million dollars. These values are in terms of 1967 dollars, adjusted by the food price index. To obtain non-deflated 1974 dollars, multiply by 1.61.

best it may try to negate the effects of these shift variables by adjusting its only instrument--total availability--in a countercyclical fashion. How successful such an activity would be is moot, since countercyclical activity may even add more instability to the supply functions.

A successful attempt to control and stabilize the total availability of FCOJ to the marketing system would reduce the effective grower supply variance, as it appears to processors,[27] by 100 percent; the processor supply variance by 92.84 percent; and the retail supply variance by 92.73 percent, i.e., $\sigma_{SSg2} = 0$; $\sigma_{SSp2} = 1.285 \times 10^{-3}$; and $\sigma_{SSr2} = 1.521 \times 10^{-3}$ gallons FCOJ per capita.[28] Table 6 summarizes the welfare gains (losses) due to market participants in the industry should the proposed Florida reserve pool be implemented. From Table 6, it may be calculated to show that of the total gains to the market participants on the supply side,

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[27]The variation in the seasonal FCOJ pack is due to weather and biological variables, as well as changes in the orange tree populations caused by economic factors on grower behavior. Since the former two variables may never be controlled by reserve pool administrators, the actual annual variation in the FCOJ pack will continue to exist. The effective grower supply of FCOJ to the marketing system will be the actual FCOJ pack less (or plus) diversions to (releases from) the reserve pool. This effective grower supply variation will be reduced by the operations of the reserve pool. It will be assumed that the administrators of the pool may stabilize this effective grower supply variance, σ_{SSg}.

[28]The disturbance terms of the processor and retailer supply functions are linear combinations of the variables TA_t, P_{t-1}, P_{t-2}, C_t, and the residuals of the functions. Reduction of the variance of the total availability variable, TA_t, to zero reduces the disturbance terms of the processor and retail supply functions to a linear combination of P_{t-1}, P_{t-2}, C_t, and the residuals of the functions. For example, the variance of the processor supply function σ_{SSp2} would be

$$\frac{1}{(18.07)^2}\left[(.2047)^2(.7416)^2 + (.2306)^2(.7409)^2 + (.3797)^2(.9717)^2 + (.2311)^2\right]$$

These values were obtained from Table 2 and Appendix Table A.5.

Table 6.--Net per capita welfare gains to the market participants of the U. S. domestic FCOJ market, with respect to the Florida reserve pool.

Market participants	Net change, in dollars per capita × 10^{-3}
Consumers	-40.23
Retailers	14.39
Processors	0.06
Growers	100.78

87.5 percent goes to growers, and 12.5 percent to retailers. Processors do not gain any appreciable welfare benefit from the exercise. As indicated earlier, the value of the processor demand quantity-price slope may possibly be underestimated. If this is truly the case, the welfare gain of processors are overestimated, in which case processors could very well have negative welfare gains, i.e., incur welfare losses. Given that the implementation of the reserve pool may possibly reduce the welfare of processors, it would be doubtful if processors would support the scheme unless they had a strong grower or growing interest.

Given a population of 212 million in 1974, the gains to growers will be 21.37 million dollars;[29] that of retailers 3.05 million dollars; and

[29]This value does not include storage and administration costs associated with the FCOJ in the reserve pool which will be charged to growers. Given an average movement of 170 million gallons of FCOJ for the coming three years, the maximum reserve pool size would be 75 million gallons. Based on the estimated costs of warehousing FCOJ for the 1973-74 season of 6.52 cents per gallon per annum (4.05 cents in 1967 dollars) growers may have to bear warehousing costs amounting to 3.04 million (1967) dollars per annum.

that of processors 0.01 million dollars. Consumer losses will amount to 8.53 million dollars.[30] These values are in 1967 dollars, adjusted by the food price index (see footnote 26, p. 65).

[30]This value relates only to the primary FCOJ market. Consumer gains as a result of special release prices for the secondary markets--such as school lunches--are not included. If the demand in the secondary markets at the special reduced prices is regarded as being perfectly elastic, welfare gains of consumers in the secondary markets would be zero. However, removal of FCOJ from the primary retail market would add to the consumer surplus losses.

CHAPTER IV
SUMMARY AND CONCLUSIONS

The Florida orange industry has been experiencing widely fluctuating prices. On-tree prices for round processed oranges from the 1957-58 season through the 1973-74 season have ranged from $0.96 to $4.43 per box, with an average of $2.06 and a coefficient of variation of 0.40.

The Florida Legislature enacted enabling legislation in 1974 for a reserve pool so that the supply of oranges, at least in the FCOJ product form, may be stabilized through the years. This study was made to evaluate the economic effects of such a reserve pool. The specific objectives were:

a) To review the literature of supply (price) stabilization studies, especially those which attempt to relate to welfare considerations;

b) To consolidate these studies and attempt to provide a generalized view on supply (price) stabilization effects on all the relevant sectors of the market--consumers, retailers, processors, and growers; and

c) To evaluate the FCOJ industry based on the conceptual model established so as to provide empirical evidence of the potential gains or losses to the market participants that may arise as a consequence of the activities of the reserve pool.

The two-party consumer-producer framework as developed by Waugh (1944), Walter Oi (1969), and Massell (1969) was extended to a four-party

case with the market participants being consumers, retailers, processors, and growers. The net welfare positions of the market participants subsequent to the introduction of a supply stabilization scheme were developed. All equations were based on a stochastic linear quantity-price relationship of supply and demand functions.

Estimates of supply and demand parameters were required in order to evaluate the net welfare position of consumers, retailers, processors, and growers subsequent to the implementation of the Florida reserve pool. A review of prior research in the industry indicated that of the three pairs of supply and demand relationships for the FCOJ markets (one pair at each market level--grower, processor, and retail), only the demand relationships at the retail and grower levels had been investigated. Estimation techniques were employed to provide the complete set of estimates required.

Orange production is a typical example of agricultural production where the annual quantities supplied may be regarded as being perfectly inelastic. In a three-tiered marketing system (grower, processor, and retail), all that remains to be determined are the five behavioral equations: processor supply, retailer supply, retail demand, retailer demand, and the processor (on-tree) demand. In the five behavioral functions. all shift variables deemed necessary were introduced. These were introduced specifically to eliminate some of the statistical problems which would otherwise occur, namely the effect of specification bias and identification problems.

Three estimation techniques were applied to the time series data (1957-58 through the 1973-74 seasons). They were the ordinary least squares (OLS), the two stage least squares (2SLS), and the three stage

least squares (3SLS) techniques. All functions estimated were formulated on a per capita basis.

The annual fluctuations in the supply of oranges were largely absorbed by the FCOJ market alone. The correlation coefficient of the annual pack of FCOJ (in box equivalents) and the total annual orange production was almost perfect (r = .992). In addition, the standard deviations of the total seasonal orange production and that of the seasonal FCOJ pack (in box equivalents) were almost equal in value. Their values were 25.23 and 25.20 million boxes, respectively. It was argued that the effect of the reserve pool on the Florida orange industry would only be reflected in the FCOJ market alone.

The FCOJ markets appear to be well behaved in that for all variables whose signs may be determined from an a priori sense, the empirical results were as expected, irrespective of estimation technique (OLS, 2SLS, and 3SLS). Further, the values of the coefficients were of the same order irrespective of estimation technique. The 2SLS estimates were used for the estimation of the welfare positions of the four market participants.

If all supply functions in the FCOJ markets were perfectly stabilized, all market participants on the supply side, namely the growers, processors, and the retailers would obtain an increase in welfare. Of the total gains, 81 percent would go to the growers, 13 percent to the retailers, and six percent to the processors. Consumers would suffer a loss equivalent to 35 percent of the total gains of the other market participants. In practice, the reserve pool has only one instrument with which it may affect the stability of the supply functions. This would be the total availability of FCOJ allowed in the market. Operating on this instrument alone, the reserve pool could theoretically reduce the

effective grower supply variance in the market by 100 percent, the processor supply variance by 93 percent, and that of retailers by the same amount. The total gains to the market participants on the supply side would be reduced, to the extent that the net welfare of processors approaches zero.

Given a population of 212 million in the United States for 1974, the net gains to growers had a reserve pool for FCOJ been implemented would be 21.37 million dollars, that of retailers 3.05 million dollars, and 0.06 million dollars for the processors. These are in 1967 dollars which are equivalent to 1.61 1974 dollars. The results suggest that it would be doubtful if processors would ever support the implementation of a reserve pool without considerable grower or growing interest.

No guideline is discernible from the Florida Concentrated Orange Juice Act, as well as from the proposed marketing order with which administrators of the reserve pool may arrive at the decision on what would be the optimal quantity to allow in the FCOJ markets. The implications that arise from this analysis could be fashioned into a set of guidelines for the use of the reserve pool administrators. First, all calculations should be made on a per capita basis. Second, once the amount of total availability of FCOJ for the industry is determined for a given season, subsequent changes may only be made in a gradual fashion so that no instability is imparted to the supply functions. The ideal position would be to maintain a stable per capita total availability level, net of imports, exports, military and government purchases through the years.

It is important to remember that the operation of the reserve pool may over time induce an unwanted producer response. The potential long-run implications of a reserve pool are explored in the next section.

Some Long-run Implications

The theoretical constructs and the subsequent analysis assumes that a reserve pool will be primarily used to stabilize the per capita FCOJ supply functions, especially at the grower level. This does not imply that prices are stabilized. The administrators of the reserve pool have no control over the shift variables operating on the demand functions, and any instability in the demand function will be reflected as fluctuations in market prices. No countercyclical activity by way of adjusting the levels of the per capita total availability of FCOJ is recommended. It is these fluctuations in supply that generate welfare losses to all market participants on the supply side of the retail market.

Supply stabilization does however, reduce price variation in the markets. The long-run effect of a reduction in price uncertainty in the FCOJ markets could be an increase in orange production[1] in Florida over and above that experienced in the past. This expanded production may possibly come from increased plantings.

Should supply be stabilized at some long-run equilibrium (average) price greater than that experienced in the FCOJ markets in the past, producers would be simultaneously offerred both higher prices as well as a reduction in price uncertainty.[2] The combined effects of the two may generate an ever increasing supply of oranges for FCOJ production in Florida, and result in an ever increasing dumping of surplus FCOJ into

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[1]Increasing shifts in supply attributed to the removal of price uncertainty has been observed. Mundlak (1964) estimated that an 83 percent shift in the poultry supply response of farmers in established family farms in Israel would occur in the long-run as a result of the removal of price uncertainty.

[2]The surplus due to consumers will, of course, decrease.

the secondary markets. Further, while the crops of Florida orange producers are subject to diversion that of orange producers in Texas, California, Arizona, and off-shore areas are not. The higher long-run price for FCOJ established by the operation of a Florida FCOJ pool may stimulate growers in competing areas to increase production and to capture a greater share of the FCOJ market. Also, if the pool is used in an attempt to increase average prices, consumers too may respond in undesirable ways over time. For example, they may press for a reduction of the tariffs placed on imported FCOJ, or they may switch to synthetic substitutes.

In view of such potential long-run problems the Florida orange industry should move very cautiously with any plans to stabilize supplies--particularly at price levels above the long-run equilibrium price trend that would exist in the absence of a pool.

Suggestions for the Administration of the Florida Reserve Pool

Assuming a stable per capita demand, a supply stabilization scheme should maintain a near constant per capita total availability of FCOJ in the FCOJ retail markets from season to season. In practice, such an activity will generally result in an inventory build-up or depletion, if possible, of the reserve pool whenever there is a difference in the rates of increase of population and in the production of oranges for processing into FCOJ. Since per capita demand is probably not stable in the real world and since differential growth rates between the quantity demanded and supplies would, more likely than not, be expected to occur, the maintenance of a constant per capita total availability of FCOJ in the retail markets from season to season would be of questionable value.

A more viable alternative for the administration of a reserve pool would be to ensure that differences between the per capita quantity demanded at long-run equilibrium prices and the quantity supplied be smoothed. In this respect the reserve pool would serve to reconcile the differences between the supply and demand shifters along the long term per capita production trend of FCOJ. Pool operations along such lines should effectively stabilize supply without incurring inventory build-ups or pool exhaustion.

The present 10 percent crop diversion limit for the proposed Florida reserve pool would provide administrators of the reserve pool with the capability to absorbe larger than expected FCOJ pack some 70 percent of the time in the next three years.[3] If the maximum crop diversion limit

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[3]A prediction equation for the annual FCOJ pack was developed (see Appendix D) to aid administrators of the reserve pool in arriving at the amount of FCOJ to be made available to the industry for a particular

is increased to 20 percent, administrators of the reserve pool may be able to achieve complete control of FCOJ in the markets from season to season.

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season. This estimating equation was based on a transformation coefficient of 1.30 gallons FCOJ per 90 pound box of oranges, tree numbers, and yield per tree as influenced by variety, age, and density of the stand.

The standard deviation of the differences between actual and predicted values was estimated to be 21.59 million gallons of FCOJ. Given an average seasonal production of oranges for the next three years to be 174 million boxes, the maximum amount of oranges that is subject to diversion is 17.4 million boxes. On the average, this would be equivalent to 22.62 million gallons of FCOJ, or 1.05 standard deviations of differences between actual and predicted quantities of seasonal FCOJ pack. Assuming that the differences are normally distributed, one would expect that administrators of the reserve pool would be successful in absorbing large orange crops some 70 percent of the time. For the remaining 30 percent, the reserve pool may act to reduce but not fully absorb deviations from the estimated trend. In this respect, the maximum 10 percent level for diversion will not be a sufficient instrument to achieve a complete stabilization of seasonal variations. A twenty percent limit would allow administrators to fully absorb large orange crops some 96 percent of the time.

Suggestions for Future Research

One assumption implicitly attached to demand functions is that consumer behavior as a function of price is perfectly reversible when prices increase and subsequently decline. Polopolus and Black (1966) argue that a non-reversible switch is more probably true for consumers of FCOJ at times of high prices. They argue that once consumers switch from citrus juices to synthetic citrus juices, the ability of the producers of the synthetic citrus beverages to maintain an exceedingly stable quality and price serves as a major barrier against any possible switch-back when FCOJ prices decline. If the argument of Polopolus and Black is accepted, a simple supply stabilization policy may not be sufficient for the needs of the Florida FCOJ industry. Supply stabilization may reduce but never eliminate price variation in the market place. This price variation will be due to the seasonal fluctuation in demand.

At times when demand is greater than normal, market prices will increase if supply is stabilized. Should the increase in market prices be excessive, product substitution may begin to occur. Total availability must be increased to prevent further price increases. Under such circumstances supply stabilization looses to price stabilization arguments.

Price stabilization may be brought about by a countercyclical adjustment of total availability, or by the imposition of a price ceiling. The latter is recommended since the former could generate more instability to the supply functions, resulting in adverse effects on the welfare of producers.

The fundamental question is whether a reversible or non-reversible

product substitution effect exists for consumer behavior in the FCOJ retail market. A secondary issue subsequent to the resolution of the first (if necessary) is the level at which the price ceiling is to be determined. In this respect the policy board of the reserve pool may ultimately be given to the stabilization of a kinked retail supply function.

A second issue is the question of inventory costs. Given an average movement of 170 million gallons FCOJ for the coming three years, the maximum pool size would be around 75 million gallons. Based on the estimated average inventory storage cost per gallon of FCOJ during the 1973-74 season of 6.52 cents per annum, a maximum annual inventory cost of 4.9 million dollars may be incurred. How much less inventory costs could be is subject to the inventory policies of the board. At this stage, only an upper bound of inventory costs is estimatable. Further research may provide a closer estimate of inventory costs given alternative inventory policies. In this respect, the simulation work such as that by Powe (1973) may be useful.

APPENDIX A
SUMMARY OF DATA

Table A.1.--On-tree prices, quantities of oranges processed, and yield in gallons of FCOJ per box for Florida oranges (Round and Temples) by seasons 1957-58 through 1973-74

Season	On-tree prices processed oranges in dollars per box[a]		Quantity of oranges processed in million boxes[a]		Yield in gallons FCOJ per box[b]
	Round	Temples	Round	Temples	
57-58	2.18	1.43	63.443	0.400	1.20178
58-59	2.89	2.48	67.565	0.948	1.40396
59-60	1.94	1.58	68.710	1.360	1.51019
60-61	2.94	2.88	67.587	1.653	1.51045
61-62	1.84	1.33	89.426	2.284	1.57517
62-63	2.58	1.57	61.073	1.172	1.09656
63-64	4.43	4.06	42.961	1.874	1.57230
64-65	2.38	2.08	67.802	1.554	1.63160
65-66	1.60	1.01	80.518	2.010	1.24090
66-67	0.96	0.16	121.624	1.998	1.36177
67-68	1.95	1.10	83.404	1.699	1.35070
68-69	1.65	1.08	116.396	2.397	1.12618
69-70	1.11	0.55	124.437	2.377	1.24030
70-71	1.42	0.83	128.338	2.768	1.20929
71-72	2.01	1.50	125.767	3.517	1.28572
72-73	1.54	0.85	157.477	2.655	1.33176
73-74	1.55	0.40	154.710	3.375	1.29725

Source: [a]Florida Crop and Livestock Reporting Service
[b]Florida Canners Association

Table A.2.--Pack, exports, purchases by military and government, inventory, and movement of FCOJ by seasons, 1957-58 through 1973-74

Season	Pack	Exports	Purchases by military and government	Inventory	Movement
	----------	----------	million gallons	----------	----------
57-58	57.151	4.460	0.657	6.719	61.635
58-59	79.911	3.608	0.643	16.605	70.096
59-60	78.149	4.688	0.559	9.663	84.941
60-61	84.358	4.202	0.577	13.631	80.405
61-62	115.845	4.904	1.209	33.750	95.748
62-63	49.468	3.602	0.828	15.399	69.998
63-64	53.668	2.464	0.533	10.136	61.386
64-65	88.853	2.864	0.960	21.814	78.665
65-66	76.695	2.999	2.146	12.828	86.568
66-67	131.754	4.538	14.823	27.225	117.758
67-68	83.687	4.150	0.605	12.885	101.681
68-69	103.750	3.770	1.233	17.400	103.528
69-70	124.947	5.468	1.412	26.566	117.236
70-71	125.187	7.664	3.626	22.567	137.743
71-72	134.229	7.328	1.873	27.750	140.715
72-73	176.073	9.529	6.749	47.372	160.552
73-74	171.846	10.665	4.222	48.861	174.956

Source: Florida Canners Association

Table A.3.--U. S. population, consumer price index, total personal disposable income, costs of FCOJ warehousing, and average retail price of FCOJ by seasons, 1957-58 through 1973-74

Season	Population in the U. S., in millions[a]	Consumer price index[a] (1967 = 100)	Total personal disposable income, in billion dollars[a]	Warehousing costs per gallon FCOJ, in cents[b]	Retail price FCOJ, in dollars per 6-oz. can[c]
57-58	174.06	86.5	317.9	2.79	.224
58-59	177.26	87.3	337.1	2.67	.212
59-60	180.68	88.6	349.9	3.13	.183
60-61	183.74	89.6	364.7	3.18	.204
61-62	186.59	90.6	385.3	4.76	.170
62-63	189.42	91.8	404.6	6.82	.250
63-64	192.10	93.0	438.1	5.25	.262
64-65	194.59	94.5	473.2	4.74	.193
65-66	196.92	97.2	511.9	5.09	.183
66-67	199.11	100.0	546.3	4.57	.146
67-68	201.18	104.2	591.0	5.88	.179
68-69	202.60	109.8	634.4	4.66	.203
69-70	204.88	116.3	689.5	5.49	.181
70-71	207.05	121.3	746.4	6.07	.185
71-72	208.84	125.3	802.5	5.09	.205
72-73	210.40	133.1	903.7	6.09	.199
73-74	211.84	147.0	979.8	6.52[d]	.204

Source: [a]U. S. Department of Commerce (1975 and earlier issues)
[b]Spurlock, Ward, and Sherrod (1974 and earlier issues)
[c]ERD, Florida Department of Citrus
[d]Lester (1974)

Table A.4.--Retail price FCOS, FOB price for FCOJ, wholesale price index, and food price index by seasons, 1957-58 through 1973-74

Season	Retail price FCOS, in dollars/gallon[a]	FOB price FCOJ at processor level, in dollars/dozen 6-oz. pack[a]	Wholesale price index[b] (1967 = 100)	Food price index[b] (1967 = 1.0)
57-58	--	1.97	94.6	.885
58-59	--	1.92	94.8	.871
59-60	--	1.54	94.9	.881
60-61	--	1.76	94.5	.891
61-62	--	1.39	94.8	.899
62-63	--	2.29	94.5	.912
63-64	.978	2.35	94.7	.924
64-65	.962	1.62	96.6	.944
65-66	.869	1.62	99.8	.991
66-67	.868	1.19	100.0	1.000
67-68	.863	1.62	102.5	1.036
68-69	.889	1.78	106.5	1.089
69-70	.881	1.56	110.4	1.149
70-71	.841	1.64	113.9	1.184
71-72	.490	1.88	119.1	1.235
72-73	.912	1.80	134.7	1.414
73-74	.906	1.82	161.7	1.610

Source: [a]ERD, Florida Department of Citrus
[b]U. S. Department of Commerce (1975 and other issues)

Table A.5.--Basic statistics of variables in the model estimated

Item	Mean	Standard deviation	Coefficient of variation
Gallons FCOJ per capita, retail and wholesale	.4976	.1269	.25
Price FCOJ per gallon at retail in dollars deflated by the food price index	4.018	.9760	.24
Price FCOJ per gallon at wholesale in dollars deflated by the food price index	2.931	.7472	.25
Price FCOJ per gallon at grower level in dollars deflated by the food price index	1.422	.6851	.48
Price FCOS per gallon in dollars deflated by the food price index	.5918[a] .8070[b]	.3903[a] .1490[b]	.66[a] .18[b]
Total availability in gallons per capita	.6132	.1764	.29
Price FCOJ per gallon at wholesale lagged one period	3.058	.7416	.24
Price FCOJ per gallon at wholesale lagged two periods	3.171	.7409	.23
Warehousing costs in cents per gallon deflated by the wholesale price index	4.818	.9717	.20
Gallons FCOJ per capita supplied by growers	.5329	.1714	.32
Deflated personal disposable income in thousands of dollars deflated by the consumer price index	2.695	.3439	.13

[a]Includes zero values as observations.

[b]Non-zero values only.

APPENDIX B
SUMMARY OF THE PROPOSED FLORIDA FCOJ RESERVE POOL

Legislation enacted by the State of Florida in 1974, entitled "Frozen Concentrated Orange Juice Pooling Act of Florida" (Florida Statutes 601.159), empowered and directed the Florida Citrus Commission to carry out the necessary processes that might bring about the implementation of a reserve pool of FCOJ within the State of Florida.

Subsequent to this legislation, the Florida Citrus Commission has drafted a proposal to be considered by the members of the FCOJ industry. Public evidentiary hearings followed whereby amendments to the proposal were considered. After the evidentiary hearings, the proposal in its amended form was subjected to a referendum and failed. At least 65 percent of the growers and 65 percent of the processors voting (the total voting representing at least 51 percent of the FCOJ traded by volume) had to favor the proposal if it were to pass.

The reserve pool was to be administered by a board comprising of ten members appointed by the Florida Citrus Commission. Five members would be growers and five would be processor members.

The types of citrus fruit that were subject to diversion would be those suitable for FCOJ and delivered to processing plants which have the capacity to concentrate the juice. All other fruit would not be subject to diversion.

The total amount of fruit to be diverted into the reserve pool was to be based on a diversion table (see Table B.1) and on the USDA October

Table B.1.--Excerpts from Attachment A to Marketing Order 105-6.01, The Diversion Table

Potential crop size column		Diversion percentage column	Potential crop size column		Diversion percentage column
Box estimate	Yield estimate		Box estimate	Yield estimate	
Mil. boxes	Gal. of 44.8° Brix FCOJ	Percent	Mil. boxes	Gal. of 44.8° Brix FCOJ	Percent
150	1.31	0	170	1.24	6
150	1.32	1	170	1.25	6
150	1.33	1	170	1.26	7
150	1.34	2	170	1.27	8
150	1.35	3	170	1.28	8
150	1.36	3	170	1.29	9
150	1.37	4	170	1.30	9
			170	1.31	10
160	1.23	0			
160	1.24	1	180	1.10	1
160	1.25	2	180	1.11	2
160	1.26	2	180	1.12	2
160	1.27	3	180	1.13	3
160	1.28	3	180	1.14	4
160	1.29	4	180	1.15	4
160	1.30	5	180	1.16	5
160	1.31	5	180	1.17	6
160	1.32	6	180	1.18	6
160	1.33	6	180	1.19	7
160	1.34	7	180	1.20	8
160	1.35	8	180	1.21	8
160	1.36	8	180	1.22	9
160	1.37	9	180	1.23	10
170	1.15	0	190	1.10	5
170	1.16	1	190	1.11	6
170	1.17	1	190	1.12	6
170	1.18	2	190	1.13	7
170	1.19	2	190	1.14	8
170	1.20	3	190	1.15	9
170	1.21	4	190	1.16	9
170	1.22	4	190	1.17	10
170	1.23	5			

crop estimate. The diversion table could have been changed annually prior to the October estimate but in any case the maximum amount that could be diverted was ten percent of the season's crop.

The optimal size for the reserve pool was set at 30 percent of the average FCOJ sales (including exports, government, and military purchases) during the 36 month period preceding July 31st of each year. The maximum size of the pool was to be 150 percent of the optimal size.

The product could be released for use in the primary (domestic) markets and the secondary markets (school and exports) (see Table B.2). The quantity to be released into the secondary market could not exceed 75 percent of the total delivered into the pool. However, 25 percent of the product delivered in the first shipping season would have to be released to the secondary market.

Releases from the pool could only be made to Florida processors. If it were released for export purposes, the processor must agree not to seek a duty drawback on an equivalent amount of imported juice.[1] All releases from the pool were to be governed by competitive bidding and the successful bid must meet the minimum release price set by the pooling board.

Certificates representing the amount of pounds solids were to be issued by the reserve pool to the last owner of the fruit as the fruit was delivered to the processing plants. Such certificates are transferable. Holders of such certificates would not receive payment from the reserve pool until all the diverted crop for that particular season is sold off. Payments made would be less deductions made for the

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[1]A tariff of 35 cents per pound solids of juice is imposed on imports. However, if the same firm that imports the juice exports the same quantity within a period of three years, 99 percent of the duty paid is recoverable.

Table B.2.--Attachment B to Marketing Order 105-6.01, Release Price Table[a]

Potential concentrate reserve figure (size of concentrate reserve pool)			Minimum release price		
Equivalent 44.8° Brix gal.		Solids	Primary market	Secondary market	Markets export
------million units-------		pounds	----------cents----------		
Up to	44	198	79	47	47
	49	221	73	45	45
	54	244	67	43	43
	59	266	61	40	41
More than	64	289	55	37	39

[a]In accordance with Section (8) (e) (3) of the act, of the total product in the concentrate reserve pool the amount of product which shall be offered for bids in any bid period governed by this release-price table shall not be less than five percent for the primary market and five percent for the combined secondary markets. However, in the event there have been no sales from the concentrate reserve pool for four calendar months immediately preceding the bidding, then of the total product in the concentrate reserve pool, 20 percent may be offered for the primary market and 20 percent may be offered for the combined secondary markets for that bid period only, provided, however, that this provision shall not apply in the first year in which the pool has inventory.

administrative costs as well as warehousing costs. The diverted product for a season would be distinguished from that of another season and all operations would be based on a first-in first-out basis.

Processors would be given the first option to act as the agents of the Commission so that the diverted fruit could be stored in their warehouses. Should processors have no place in their warehouses, or were unwilling to carry the diverted product, the Commission was authorized to lease storage facilities.

Had the referendum been successful, another referendum would have to be held after three years if the reserve pool is to continue under the legislation. A pool may be terminated at any time upon a vote by nine members of the Board.

APPENDIX C
PROOF OF FORMULAE USED

(2.3a) From Figure 4a (i.e., when $B \geq 0$)

$$S_p = P_e B + P_e\left(\frac{Q_e - B}{2}\right)$$

$$= P_e\left(\frac{Q_e + B}{2}\right)$$

$$= \left(\frac{Q_e - B}{b}\right)\left(\frac{Q_e + B}{2}\right), \text{ by the definition of the supply function}$$

$$= \frac{Q_e^2 - B^2}{2b}$$

(2.3b) From Figure 4b (i.e., when $B < 0$)

$$S_p = \left(P_e + \frac{B}{b}\right)\frac{Q_e}{2}$$

$$= \frac{Q_e^2}{2b}, \text{ by the definition of the supply function}$$

(2.4) From Figure 4a (or 4b)

$$S_c = \frac{Q_e}{2}\left(\frac{A}{a} - P_e\right)$$

$$= \frac{Q_e}{2}\left(\frac{A - A + Q_e}{a}\right), \text{ from the definition of the demand function}$$

$$= \frac{Q_e^2}{2a}$$

(2.8a) From (2.3a), keeping in mind that an error term v is associated with B

$$S_p = \frac{Q_e^2 - (B + v)^2}{2b}$$

$$= \frac{(\bar{q} + e_2)^2 - (B + v)^2}{2b}, \text{ using (2.7b)}$$

$$= \frac{\bar{q}^2 + 2\bar{q}e_2 + e_2^2 - (B^2 + 2Bv + v^2)}{2b}$$

$$= \frac{\bar{q}^2 - B^2}{2b} + \frac{2\bar{q}e_2 + e_2^2 - v^2 - 2Bv}{2b}$$

(2.8b) From (2.3b)

$$S_p = \frac{Q_e^2}{2b}$$

$$= \frac{(\bar{q} + e_2)^2}{2b}$$

$$= \frac{\bar{q}^2}{2b} + \frac{2\bar{q}e_2 + e_2^2}{2b}$$

(2.9a) $$E(S_p) = \frac{\bar{q}^2 - B^2}{2b} + \frac{E(e_2^2) - E(v^2)}{2b}$$

$$= \frac{\bar{q}^2 - B^2}{2b} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2b(a + b)^2} - \frac{\sigma_{SS}}{2b}, \text{ from (2.7b) and (2.6e)}$$

$$= \frac{q^2 - B^2}{2b} + \frac{b^2\sigma_{DD} - (b^2 + 2ab)\sigma_{SS}}{2b(a + b)^2}$$

$$= \frac{\bar{q}^2 - B}{2b} + \frac{b\sigma_{DD} - (b + 2a)\sigma_{SS}}{2(a + b)^2}$$

(2.9b) $$E(S_p) = \frac{\bar{q}^2}{2b} + \frac{E(e_2^2)}{2b}$$

$$= \frac{\bar{q}^2}{2b} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2b(a + b)^2}, \text{ from (2.7b)}$$

(2.10) From (2.4)

$$S_c = \frac{Q_e^2}{2a}$$

$$= \frac{(\bar{q} + e_2)^2}{2a}$$

$$= \frac{\bar{q}^2}{2a} + \frac{e_2^2 + 2e_2\bar{q}}{2a}$$

(2.11) $$E(S_c) = \frac{\bar{q}^2}{2a} + \frac{E(e_2^2)}{2a}$$

$$= \frac{\bar{q}^2}{2a} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2a(a + b)^2}, \text{ from (2.7b)}$$

(2.12a) $$E(S_T) = E(S_p) + E(S_c)$$

$$= \frac{(a + b)\bar{q}^2 - aB^2}{2ab} + \frac{b\sigma_{DD} - (b + 2a)\sigma_{SS}}{2(a + b)^2} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2a(a + b)^2}$$

if $B \geq 0$

$$= \frac{(a + b)\bar{q}^2 - aB^2}{2ab} + \frac{ab\sigma_{DD} - a(b + 2a)\sigma_{SS} + a^2\sigma_{SS} + b^2\sigma_{DD}}{2a(a + b)^2}$$

$$= \frac{(a + b)\bar{q}^2 - aB^2}{2ab} + \frac{(a + b)b\sigma_{DD} - (a + b)a\sigma_{SS}}{2a(a + b)^2}$$

$$= \frac{(a + b)\bar{q}^2 - aB}{2ab} + \frac{(b\sigma_{DD} - a\sigma_{SS})}{2a(a + b)}$$

(2.12b) $$E(S_c) = E(S_p) + E(S_c)$$

$$= \frac{(a + b)\bar{q}^2}{2ab} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2b(a + b)^2} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2a(a + b)^2} \text{ if } B < 0$$

$$= \frac{(a + b)\bar{q}^2}{2ab} + \frac{a^2\sigma_{SS} + b^2\sigma_{DD}}{2ab(a + b)}$$

APPENDIX D
PREDICTING THE SEASONAL PACK OF FCOJ

If the growers and the processors implement a reserve pool in the FCOJ industry, administrators of that pool will be faced with the problem of having to decide on the amount of the orange crop that is to be diverted to, or released from, the pool at the beginning of each season. These decisions must be made each year after the crop size estimates are released by the USDA when there is some idea of the total FCOJ pack.

The amount of FCOJ to be made available to the industry is subject to many considerations, but primarily, it will be determined by the average consumption per capita, the existing inventory in commercial hands, and the population size. If the long-run production trend in oranges is increasing at the same rate as the population, administrators of the pool need not worry about an inventory build-up or the exhaustion of the pool, provided the seasonal variation is distributed with a mean value of zero. If the long-run production trend exceeds that of the population, the amount per capita to be made available annually to the industry must be increased, or the inventory in the pool will rise with each succeeding season.

In this appendix an attempt is made to predict production trends over a period of seasons, and to test whether deviations from this trend have a zero mean.[1] Estimates of trend and the deviations from it provide

[1]Production trends for Florida orange production have been estimated by Lester and Polopolus (1972), and by Lester and Ward (1975). The latter

some information about the potential size of the task of managing the reserve pool.

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is the update of the former. In both studies, production trends estimated were based on tree age and numbers, average yields, and seasonal weather influences. The latter was generated by a random sampling technique on a predefined symmetric distribution.

Prediction Equations

Seasonal Production of Oranges

The total amount of oranges produced in Florida for any given season may be expressed as (D.1).

$$\text{(D.1)} \quad O_{Tt} = qA_t + z_{1t}$$

where O_{Tt} = total number of boxes of oranges produced during season t

q = average yield per acre, in boxes

A_t = total bearing acreage at season t

z_{1t} = error term

Koo et al. (1958, p. 22) have found that the average yield per acre is not stable, but is affected by the planting density. Yields per tree appeared to be more stable relative to the planting density. They state,

> There was very little difference in fruit production when the data were expressed in boxes per tree in the range from 45 to 84 trees per acre. . . . However, when the data are expressed as boxes per acre, the increase in yield is proportional to the number of trees planted on an acre up to the 75 to 84 trees per acre range. Further increase in the number of trees per acre resulted in a lower yield . . . .

Expression (D.1) therefore, will be modified by using the more stable yield per tree parameter in place of the average yield per acre parameter.

While the yield per tree is relatively stable with respect to tree desities in stands of less than 84 trees per acre, it does vary with variety as well as with stand. From Table D.1, the effects of variety and age on yield per tree may be observed. Since yield per tree increases with increasing age, the yield per tree parameter will have a distribution with respect to age. From Table D.2 it was also observed that tree densities in recent years have been exceeding the 84 trees per acre

Table D.1.--Average yield of Florida oranges per tree by age class and variety, eight year season average, 1965-66 through 1973-74[a]

Variety	Years			
	4 - 9	10 - 14	15 - 24	25 and older
	----------boxes per tree----------			
Early and Midseason	1.291	2.444	4.138	5.353
Valencia	1.087	2.213	3.389	4.500

[a]Calculated from Florida Crop and Livestock Reporting Service, Fruit Per Tree, October 1973 and November 1974 issues.

Table D.2.--Tree density per acre of Florida commercial oranges, by age and by variety in December 1973[a]

Age	Varieties		
	Early and Midseason	Valencias	Temples
	----------trees per acre----------		
0	92.6	89.9	99.9
1	49.7	115.4	90.1
2	103.1	100.3	107.0
3	119.2	113.6	120.2
4	111.4	109.3	102.3
5	106.0	105.2	108.1
6	105.7	107.1	116.4
7	99.4	101.6	103.7
8	92.8	96.2	104.7
9	88.6	91.9	96.0
10	83.1	86.8	91.8
11	81.2	83.5	97.3
12	81.7	83.8	84.9
13	79.9	80.1	73.5
14	76.3	75.4	70.7
15	76.1	76.8	77.3
16	73.5	73.4	84.2
17	75.1	78.6	82.8
18	74.2	75.5	79.5
19	72.4	76.3	83.7
20	73.8	73.3	75.5
21	72.2	74.0	76.5
22	70.2	68.9	81.4
23	70.6	71.2	78.2
24 and above	71.9	69.5	77.6

[a]Calculated from Florida Agricultural Statistics: Commercial Citrus Inventory. Unidentified oranges prorated between the Early and Midseason, and Valencia types in proportion to their tree numbers.

density level. In view of these findings, adjustments were made to the yield per tree estimates given in Table D.1 as the age and tree density increases. Expression (D.1) was adjusted accordingly to (D.2).

$$\text{(D.2)} \quad O_{Tt} = \sum_{v}\sum_{a}\sum_{d} Y_{vadt} N_{vadt} + z_{2t}$$

where Y_{vadt} = average yield per tree, of variety v, aged a, in stands of density d, during season t

N_{vadt} = corresponding number of trees

z_{2t} = error term

Yield per tree

Phillips (1975) has recorded the effect of density and age on yields, at least in the early stages of the productive life for one Early and Midseason variety. This is reproduced in Table D.3. In order to obtain estimates of yield per tree for densities between 87 trees per acre and 145 trees per acre as well as for densities below 87 trees per acre, the yields given in Table D.3 were regressed, using the OLS technique, on age and density of the stand.[2] From the resulting regression equation obtained, the values of Table D.4 were calculated.

The Florida Crop and Livestock Reporting Service (FCLRS) yield per tree data in Table D.1 was consistently less than the yield per tree estimates obtained from the Phillips data for the Early and Midseason variety. For a basis of comparison, the FCLRS yield per tree data was assumed to

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[2]The regression equation estimated was quadratic in both age and density. The coefficient of determination obtained was 0.8050. The addition of a first order interaction term did not alter the value of the coefficient of determination. Thus no interaction term of age and density was included.

Table D.3.--Estimated effect of density and age on yield per acre

Trees/ acre	Age in years							
	5	6	7	8	9	10	11	12
	boxes per acre							
87	144 a	128 a	212 a	285 a	450 a	305 a	480 a	376 a
145	222 b	208 b	326 b	434 b	599 b	436 b	703 b	573 b
290	360 c	269 c	619 c	551 c	708 c	583 c	812 c	582 c

Source: Phillips (1975), Table 3.

Note: a, b, c: Means within a column followed by different letters are significantly different at the five percent level.

Table D.4.--Estimated effect of density and age on yield per tree

Density	Age					
	7	8	9	10	11	12
	boxes per tree					
84	2.77	3.61	4.25	4.69	4.94	4.99
87	2.77	3.58	4.20	4.63	4.87	4.92
90	2.77	3.56	4.16	4.57	4.80	4.85
93	2.77	3.53	4.11	4.51	4.74	4.78
95	2.77	3.51	4.07	4.46	4.67	4.72
98	2.77	3.48	4.03	4.40	4.61	4.66
101	2.76	3.46	3.99	4.35	4.56	4.60
104	2.76	3.43	3.95	4.30	4.50	4.54
107	2.75	3.41	3.91	4.25	4.45	4.48
111	2.75	3.38	3.86	4.21	4.39	4.43
114	2.74	3.36	3.83	4.16	4.34	4.38
117	2.73	3.33	3.80	4.11	4.29	4.33

Note: Estimating equation used: $y = -1023.14 + 4.18055D - .00765247D^2 + 195.087A - 8.30157A^2$ where y = yield per acre, D = trees per acre, and A = age of stand.

be representative of trees in plantings with densities of 84 trees or less per acre. Table D.5 illustrates the differences in estimates of yield per tree between the two reporting sources. An average[3] of the two was used as the yield per tree estimate. Changing the values of the appropriate cells in Table D.1 gives Table D.6. Applying linear interpolation to the data of Table D.6, a distribution of yield per tree by age for trees in plantings of 84 trees per acre and less were obtained. Figure D.1 illustrates the linear interpolation technique used. Table D.7 summarizes the values of yield per tree by age for trees in plantings of 84 trees and less. It includes the distribution of yield per tree for the Temple variety. The latter is a six season average (1965-66 through 1970-71) calculated from estimates made for each of the seasons by Lester and Polopolus (1972).

For trees in plantings exceeding 84 trees per acre, it was assumed that tree yields would be affected by tree density when the trees reach seven years of age (see Table D.4). As trees mature, tree removals occur. Since the Phillips data only extended to trees of age twelve, that was the age for which it was assumed that tree densities would be reduced to the planting density of 84 trees per acre, or less; in which case no more adjustments to tree yields due to densities is required. Yield per tree adjustments made were based on the ratio of tree yields obtained from Table D.4. It was also assumed that Valencias and Temples, the other

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[3]Averaging is also desired because the Phillips data, being derived from trees in an experimental station, is generally biased on the positive side if used as a measure for field measurements. The FCLRS data, however, was recorded for trees without respect to density of the stand. The higher initial planting densities in the field biases the results on the negative side. An average of the two hopefully will remove the opposing biases.

Table D.5.--Yield per tree by age class, as estimated by FCLRS and Phillips

Source	Age class:	4 - 9	10 - 14
	Midclass value:	6.5	12
		-----boxes-------	
FCLRS		1.291	2.444
Phillips data (84 trees/acre)		2.278	4.996
Average		1.784	3.720

Table D.6.--Estimated yield per tree by age class and variety

Variety	Years			
	4 - 9	10 - 14	15 - 24	25 and older
	----------boxes----------			
Early and Midseason	1.784	3.720	4.138	5.353
Valencia	1.087	2.213	3.389	4.500

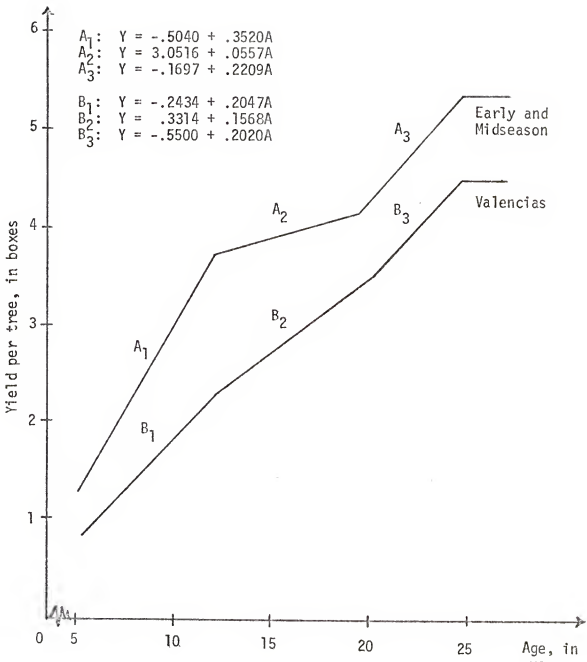

Figure D.1.--Estimated average yield of Florida orange trees, by age and variety

Table D.7.--Estimated yield per tree, by variety and age for Florida oranges

Age (years)	Variety		
	Early and Midseason	Valencias	Temples[a]
	----------boxes----------		
0-3	0	0	0
4	.904	.575	.70
5	1.256	.780	.88
6	1.608	.985	1.07
7	1.960	1.189	1.18
8	2.312	1.394	1.31
9	2.664	1.599	1.42
10	3.016	1.804	1.54
11	3.368	2.008	1.66
12	3.720	2.213	1.77
13	3.776	2.370	1.92
14	3.831	2.527	2.08
15	3.887	2.683	2.23
16	3.943	2.840	2.39
17	3.998	2.997	2.55
18	4.054	3.154	2.70
19	4.110	3.312	2.97
20	4.248	3.490	3.24
21	4.469	3.692	3.50
22	4.690	3.894	3.77
23	4.911	4.096	4.04
24	5.132	4.298	4.31
25 and over	5.353	4.500	4.58

[a]From Lester and Polopolus (1972).

two orange varieties considered in the analysis, would follow the same yield corrections made for the influence of densities on the Early and Midseason variety.

Tree numbers

Tree numbers by age and by variety for any particular season were obtained from the biennial aerial photographic survey carried out in odd years (beginning 1965) by the FCLRS, Orlando, Florida. The number of trees by age for even years were obtained by linear interpolation. Where linear interpolation was not applicable, adjustments were made by making use of the estimated annual tree removal rate estimated from the tree surveys, with the assumption that the relationship between the two follows the compounding rule.[4] Unidentified trees were prorated between the Valencias and the Early and Midseason type in proportion to the tree numbers of each of the two varieties.

Seasonal FCOJ Pack

If one writes O_{Tt} as the total amount of oranges produced in Florida, O_{Ft} the amount of oranges produced going into the FCOJ market, and O_{Nt} the amount going into the non-FCOJ markets, the following identity may be written.

$$\text{(D.3)} \quad O_{Ft} = O_{Tt} - O_{Nt}$$

Substituting (D.2) into (D.3), one obtains (D.4). As observed earlier, O_{Nt}, the amount of aranges disposed of in the non-FCOJ markets has been very stable, and for all practical purposes may be regarded as a constant.

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[4] $(1 - B) = (1 - A)^2$, where B = biennial removal rate, A = annual removal rate.

$$\text{(D.4)} \quad O_{Ft} = \sum_{vad}\sum\sum Y_{vadt} N_{vadt} - O_{Nt} + z_{2t}$$

The unit of the supply function as defined will be in boxes of oranges. However, gallons of FCOJ at 45 degrees Brix is favored because the proposed pooling board diversion activities will be based on the total estimated production in terms of that measure.[5] By transforming the boxes of oranges estimated from (D.4) into pounds solids and then dividing by 4.5120, the annual pack of FCOJ in gallons may be obtained. Table D.8 gives the average pounds solids per box of oranges for the various seasons. Since the pounds solids vary from season to season, the direct transformation coefficient also changes from season to season. Rewriting (D.4) as (D.5), the prediction equation for the annual FCOJ pack is obtained.

$$\text{(D.5)} \quad Q_{gt} = (\gamma + z_{3t}) O_{Ft}$$

$$= \gamma\left(\sum_{vad}\sum\sum Y_{vadt} N_{vadt}\right) - \gamma O_{Nt} + z_{4t}$$

where Q_{gt} = supply of oranges to processing plants during season t, in gallons FCOJ equivalents

γ = average value of the transformation coefficient, from boxes of oranges to gallons FCOJ

z_{3t}, z_{4t} = error terms

The average value of the transformation coefficient γ may be obtained from Table D.8 while O_{Nt}, the average annual quantity of oranges disposed of into the non-FCOJ markets, was calculated from Table 1.

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[5]See Attachment A to Marketing Order 105-6.01, partially reproduced in Appendix B as Table B.1.

Table D.8.--FCOJ yields per box for Florida oranges[a] by seasons, 1960-61 through 1973-74

Season	Pound/solids	Gallons
60-61	6.277	--
61-62	6.546	--
62-63	4.557	--
63-64	6.534	--
64-65	6.781	--
65-66	5.599	--
66-67	6.144	--
67-68	6.094	--
68-69	5.081	--
69-70	5.596	--
70-71	5.456	--
71-72	5.801	--
72-73	6.009	--
73-74	5.853	--
Average	5.881	1.303[b]

[a]Includes Temples and Round oranges.

[b]Calculated using conversion of 4.5120 pounds solids to the gallon.

Source: Florida Canners Association Statistical Summary

Performance of the Prediction Equations

The extent to which the prediction expressions (D.2) and (D.5) 'fits' historical data would provide some idea of the strengths and weaknesses of the equations. An ideal prediction equation would be one that gives predictions with the least error, as well as having an error distribution with a zero mean. The need of having an error distribution with a zero mean is especially important when supply stabilization schemes are to be administered; it means that on average, the reserve pool would not have a consistent inventory build-up or depletion if the pool administration board makes decisions based on the predicted quantities.

Seasonal Orange Production

Table D.9 provides the estimated annual production of Florida oranges from expression (D.2), the predicting equation for orange production.

The difference between actual and estimated production, the latter being a function of varietal type, tree number, tree density, and age, provides some idea as to the influence of other variables not considered on annual Florida orange production. They account for 35.7 percent[6] of the total annual fluctuations. Assuming that agronomic practices have been stable during the seasons from 1965 through 1973, it may be inferred

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6 $\left(\frac{\Sigma \hat{u}_t^2}{\Sigma O_t^2 - (\Sigma O_t)^2/n}\right) \times 100$ = percentage of total seasonal variation due to weather influences

where $\hat{u}$ = difference between actual and estimated production during season t

O_t = actual orange production

n = number of seasons considered

Table D.9.--Actual and estimated seasonal production of Florida oranges, 1965-66 through 1973-74 with estimates extending through 1977-78

Season	Actual[a]	Estimated long-run	Estimated stochastic disturbance
	----------million boxes----------		
65-66	100.4	113.49	-13.09
66-67	144.5	119.72	24.78
67-68	105.0	129.30	-24.30
68-69	134.2	136.62	-2.42
69-70	142.9	147.42	-4.52
70-71	147.3	152.65	-5.35
71-72	142.3	156.42	-14.12
72-73	174.8	161.89	12.91
73-74	171.1	166.77	4.33
74-75	--	170.81	--
75-76	--	173.79	--
76-77	--	176.55	--
77-78	--	178.44	--

[a]From Florida Crop and Livestock Reporting Service Citrus Summary 1973, and Annual Production and Value, October 1974.

that the "unexplained" portion of the annual fluctuation in production is due primarily to changing weather conditions. The data in Table D.9 are graphed in Figure D.2.

The net effect of weather variables on annual orange production is distributed in such a manner as to be consistent with the assumption of a zero mean. A t test on the hypothesis that the mean of the unexplained portion of the total annual production is zero gave a calculated t statistic of -.4821. Since the tabulated t value ($\alpha = 0.05$, df = 8) is 1.860, the validity of the assumption of a zero mean was supported.[7]

When this result is taken in conjunction with that of Parvin (1970), interesting implications follow. Parvin has estimated the effects that weather have on Florida orange production. He has drawn the conclusion that weather could depress (or increase) annual yields by 33 (32) percent for Early and Midseason types and by 40 (22) percent for Valencias. This gives an aggregated factor of 36 (28) percent for the state.[8] Given the range and mean value, an inference on the distributional form of weather

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[7] $t = \frac{\bar{u}}{S_{\bar{u}}}$, where $\bar{u}$ = mean of differences between actual and estimated production

$S_{\bar{u}}$ = standard error of $\bar{u}$

$$t = \frac{-2.420}{5.02} = -.4821$$

Similar results were also obtained by applying the same analysis to the production trend of Florida oranges as estimated by Lester and Polopolus (1972), and updated by Lester and Ward (1975). A calculated t value of 1.1439 was obtained while the tabulated t value ($\alpha = 0.05$, df = 5) was 2.015.

[8] A weighted index obtained by assuming that the Valencia crop is 80 percent of the Early and Midseason types. These were the proportions observed for the 1973-74 season.

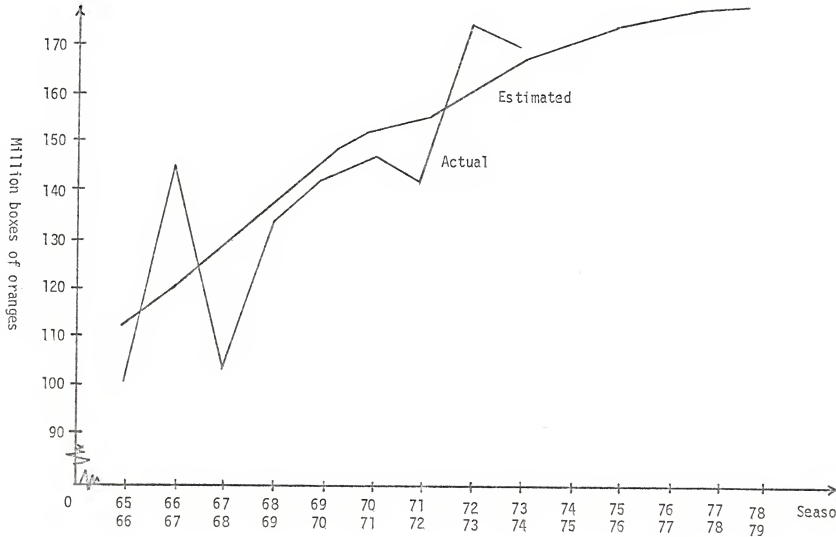

Figure D.2.--Actual and estimated seasonal production of Florida oranges.

effects on production may be made. If the distributional form is assumed to be simple, then a symmetric distribution may possibly be the case.[9]

Seasonal FCOJ Pack

The amount of FCOJ processed for each season was estimated from expression (D.5). The error term z_{4t} of the same expression is a simple linear combination of the error terms z_{2t} and z_{3t}, plus the simple product of the two. This product will not be expected to be zero since both are error terms related to weather. It was evaluated to be 0.32 million gallons of FCOJ. Removing this value from the error term z_{4t} (by adding it to the value of 0_{Nt}), the modified error term of z_{4t} will be only a linear combination of the error terms z_{2t} and z_{3t}. If the weather effects are distributed with a mean of zero, the modified error term will be expected to have a mean value of zero too. From Table 1, the value of 0_{Nt} was calculated to be 41.834 million boxes. Using these values, a transformation coefficient of 1.30 gallons FCOJ per box of oranges, and the predicted quantities of oranges produced (as tabulated in Table D.9), Table D.10 and Figure D.3 were obtained.

When the predicted seasonal FCOJ pack was compared against actual values realized in the past, it was found that the prediction expression for FCOJ could account for 60.41 percent of the annual variation in FCOJ production.

Again, the distribution of the residuals appear to support the hypothesis that their mean value is zero. The t statistic obtained is

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[9]The assumption of a symmetric (equal probability) distribution for weather effects made by Polopolus and Lester (1968) appears to be even more valid in the light of this and Parvins' study.

Table D.10.--Actual and estimated seasonal pack of FCOJ by seasons, 1965-66 through 1973-74 with estimates extending through 1977-78

Season	Actual[a]	Estimated[b]	Stochastic disturbance
	----------million gallons----------		
65-66	76.6	92.9	-16.2
66-67	131.8	101.0	30.8
67-68	83.7	113.5	-29.8
68-69	103.8	123.0	-19.2
69-70	124.9	137.0	-12.1
70-71	125.2	143.8	-18.6
71-72	134.2	148.7	-14.5
72-73	176.1	155.8	20.3
73-74	171.1	162.2	9.6
74-75	--	167.4	--
75-76	--	171.3	--
76-77	--	174.9	--
77-78	--	177.4	--

[a]From Florida Canners Association Statistical Summary.

[b]Using expression (D.5).

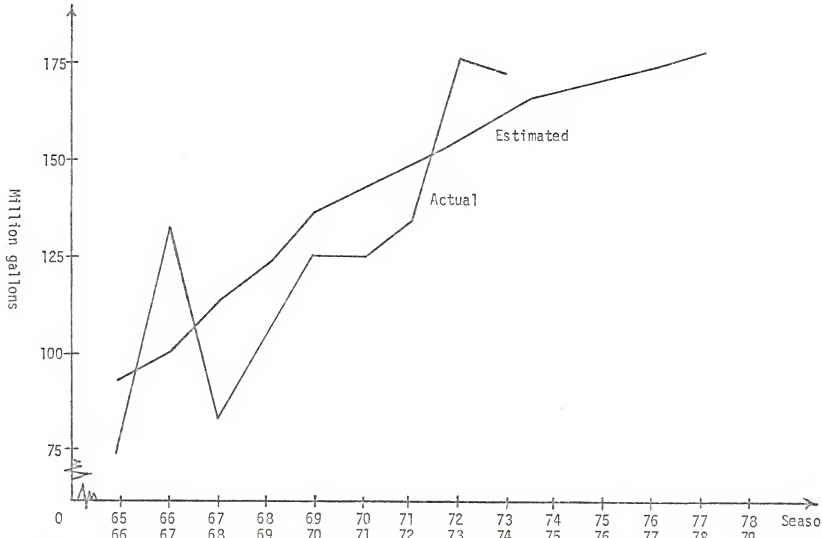

Figure D.3.--Actual and estimated seasonal pack of FCOJ, in million gallons

-0.8460 while the tabulated t value is 1.860 ($\alpha = 0.05$, df = 8). The variance was estimated to be 466.16 million gallons.[10]

[10] $\bar{u} = -6.089$; $S_u = 21.591$; $S_{\bar{u}} = S_u/\sqrt{n} = 7.197$.

Implications for Reserve Pool Operations

As the differences between the actual and estimated seasonal FCOJ pack are distributed with a mean of zero, administrators of a reserve pool will not, on the average, suffer from an inventory build-up in the reserve pool, or from the depletion of the latter whenever they make decisions based on the predicted quantities of the seasonal FCOJ pack given by expression (D.5).

The standard deviation of the differences between actual and predicted values was estimated to be 21.59 million gallons of FCOJ. Given an average seasonal production of oranges for the next three years to be 174 million boxes, the maximum amount of oranges that is subject to diversion is 17.4 million boxes. On the average, this would be equivalent to 22.62 million gallons of FCOJ (using a transformation of 1.3 gallons per box of oranges), or 1.05 standard deviations of the differences between actual and predicted quantities of seasonal FCOJ pack. Assuming that the differences are normally distributed, one would expect that administrators of the reserve pool would be successful in absorbing large orange crops some 70 percent of the time. For the remaining 30 percent, the reserve pool may act to reduce but not fully absorb deviations from the estimated trend. In this respect, the maximum 10 percent level for diversion will not be a sufficient instrument to achieve a complete stabilization of seasonal variations. A twenty percent limit would allow administrators to fully absorb large orange crops some 96 percent of the time.

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BIOGRAPHICAL SKETCH

Oon Lee Yeoh was born November 8, 1942, in Penang, Malaysia. After attending the public schools in various parts of Pahang and in Penang, he entered the University of Malaya in 1963. In March 1966, he received the degree of Bachelor of Agricultural Science. At the same time he was also awarded a Fellowship by the Agricultural Development Council, New York, to the Economics Institute, Boulder, Colorado (June-August 1966), and to the North Carolina State University at Raleigh. Graduating with a Master of Science from North Carolina State in 1968, he returned to Malaysia where he worked as an Assistant Lecturer (subsequently Lecturer) at the Faculty of Agriculture, University of Malaya. In 1971, he was again offered a Fellowship by the Agricultural Development Council to pursue a program of work towards the degree of Doctor of Philosophy at the University of Florida. Since 1972, he has been at the University of Florida pursuing the same. He is a member of the American Agricultural Economics Association and Gamma Sigma Delta, the American Honor Society of Agriculture. He is married and has one son.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Max R. Langham, Chairman
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Leo Polopolus
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James A. Niles
Assistant Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June, 1975

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